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100% SOLID STATE

4TH EDITION

the low and medium frequency radio scrap book

Dedicated to the Experimenter

AUTHORS NOTE:-

THIS SCRAPBOOK EDITION IS "CHOCK-FULL" OF SIMPLE CIRCUITS AND DATA USEABLE IN THE LOW FREQUENCY RADIO SPECTRUM. MANY ARE ALSO APPLICABLE TO THE LOWER FREQUENCY AMATEUR RADIO BANDS.

CONVERTERS, PRE-AMPLIFIERS, ACTIVE ANTENNAS, LOOPS, FACTS AND DETAILS ON COILS AND COIL WINDERS, TRANSMITTERS FOR THE NONLICENSED COMMUNICATION BANDS 160 TO 190 kHz AND 510 to 1600 kHz, AND THE FCC RULES COVERING SAME.

KEN CORNELL, W2IMB

THE LOW AND MEDIUM FREQUENCY RADIO SCRAPBOOK

4th EDITION

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FORWARD

This edition of my scrapbook, as previous editions, is dedicated to the radio experimenter.

There are all types of hobbies....Many seasonal, most are expensive, yet exploring radio communications, in my mind, is one of the most satisfying experiences that one can enjoy within the comfort of your own home at the "flick of a switch".

The groweth of amateur radio stations worldwide and the popularity of the citizen band has far outreached even the most optimistic estimates made years ago.

Commercial manufactured equipment for the enjoyment of the radio hobby is quite expensive and it is my opinion that the use of some of the devices I describe herein, by the use of a soldering iron and a few cheap parts, to be able to extend the tuning range and effectiveness of this equipment.

Many of the devices I describe are also applicable to the amateur radio bands, particularly 160, 80 and 40 meters.

Some of the basic information concerning coils and antennas in the various chapters may sound slightly repititious, but it is done on purpose as I would rather repeat an important point where necessary than to neglect it.

I sincerely hope that the average reader of this manuscript enjoys it at least half as much as I had fooling with the various devices and the preparation of the text.

73

Ken Cornell, W2IMB

Ken

PS:- I never majored in English so please excuse some spelling errors and poor composition.

THE LOW & MEDIUM FREQUENCY RADIO SCRAPBOOK

4th Edition

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INTRODUCTION:-

The following text is the result of many years of experimental probing into the radio spectrum that lies within the existing AM broadcast band (510 to 1600 kHz) and the lower frequencies that exist between 510 to below 10 kHz.

For over 50 years, most radio buffs attention has been directed to the higher frequencies with its world-wide coverage and somewhat predictable "skip conditions".....Then came VHF and UHF and the lower frequencies were for all practical purposes, a forgotten portion of the radio spectrum....BUT ARE THEY ?

Not by a "golly darn"....There are thousands of authorized radio services operational in the low frequency range including airport and navigational beacons, frequency standards, foreign broadcast stations and other services that are detectable on a fairly efficient receiving system.

The above paragraph is mainly directed to buffs that enjoy twisting a dial and logging new stations (converted SWL's ?)....However, there is another phase of the low frequency radio bit, namely that the FCC will permit the use of non-licensed radio transmitters that can be used for communication purposes within the AM Broadcast band and the 160 to 190 kHz Band....This communication capability permitted by the FCC in Section 15 of their rules and regulations, attracted my original interest back in 1970.

In the early '70s, I met a very small group of experimenters via Ham Radio that were located within my area (Westfield, NJ) that were in the process of fooling around with communications on the 160 to 190 kHz band using one watt of input power and a 50 foot long antenna. While it took me several weeks to get a signal out of my "back yard" I finally made it and was amazed at what that "LIL" one watt signal can do !....The rest is history, as there are untold numbers of what I call "LOWFERS" (short for Low Frequency Experimental Radio Station). Communications in the 100 to 200 mile range is not uncommon using CW, and using DSB or SSB voice communications (suppressed carrier) in the 50 mile range and I have had reports that some stations on the West Coast have communications using AM in the 15 mile range.

In the Broadcast Band (510 to 1600 kHz), I have received no reports of DX activities, except to say, that I ran a CW Beacon on 1585 kHz using 100 milliwatts of power and a 10 foot long vertical antenna several years ago and a friend in Lincroft, NJ @ over 10 miles was able to copy my beacon QS regularly....I am sure that my 1585 kHz signal didn't "drop dead" in his back yard ?....How much farther, who knows ?....The point is that what we LOWFERS are doing is LEGAL and we need more activity to evaluate the possibilities of how these frequencies can be used for personal and public communication gains.

I was very enthusiastic about what our small group of LOWFERS were accomplishing and when I mentioned our activities to other Hams on the various bands, the other party in most cases was not aware of the operational priviledge permitted by the FCC on the 160 to 190 kHz band and wanted more information on same....In 1972 I published a mini-handbook containing basic facts, simple circuits and the FCC rules and it was well received....In fact 10 years later, I still get occasional orders for the publication @ $2 per copy.

During the next 4 years, I published a more sizeable text, namely the 2nd and 3rd editions of my Low and Medium Frequency Radio Scrapbook. These were followed by my Addendum '77/'78 that contained new data and circuits with necessary up-dating.

This series was highly vacuum tube oriented as to most active circuits whereas this 4th edition is 100% solid state....My experiences with both tubes and solid state devices in the LF range leaves me with very mixed emotions and in some respects, I feel sorry for the new generation of radio experimenters that have never been exposed to vacuum tube theory or the applications of same....However, it is not the intent of this text to get into any arguments....Hi !

In 1974 I became aware of a small group on the West Coast that had started a club called the Longwave Club of America and they issued a monthly publication called the LOWDOWN....I felt that such a group with a monthly publication would be ideal for bringing the scattered LOWFERS and LF Buffs together for a mutual exchange of information and activities....I joined the club and shortly thereafter became the 1750 Meter column editor.

The club over the years has grown to a membership of some 500 and the LOWDOWN has become quite a respectable publication containing articles of both technical and non-technical in nature as well as loggings that are sent in by members (station listings, frequency, location, etc.). It also contains want and sell adds (free to members) and the Mailbag contains letters from members with lots if interesting information. It is really a MUST reading for anyone interested in the LF range.

Annual dues is $10....Send check or M.O. to William E. (Bill) Oliver, 45 Wildflower Road, Levittown, PA 19057....Bill is the publisher of the LOWDOWN.

Another interesting publication sponsored by the LWCA is the BEACON GUIDE compiled by H. John Clements and edited by Ken Stryker and it took years of research to publish a list of some 5500 operational Aircraft, Marine, Private and Offshore Beacons located in the Western Hemisphere from Asia and Australia to the Azores and from Alaska to the Antartic....The publication is available from Century Print Shop, 6059 Essex Street, Riverside, CA 92504 for $7 per copy postpaid USA and $8 by International Money Order for Canada....I might add that necessary up-dating to the Guide is included from time-to-time in the LWCA's monthly publication, the LOWDOWN.

I wish to make an important point that all editions of my scrapbooks are directed to experimenters that have a reasonable background in

theory and practice....There are too many fine books published that contain electronics theory and application of various devices that are not compatable to this type of publication.

An operational transmitter in the low frequency range, regardless of power, in the wrong hands could cause serious interference if off frequency from 160 to 190 kHz, to aircraft and marine beacons that can be navigational aides....If you don't have the proper "know-how" and proper equipment to check your operational frequency, PLEASE inlist the aide of soneone that does !

S'funny, but I occasionally get mail wherein the correspondent tells me that they are building a transmitter and have some questions about my circuits....Yet in the next breath, they mention that they don't have a receiver ?....Talk about putting a cart in front of a horse !

I really appreciate the mail I receive from readers of my scrapbook series, but I would like to make a few suggestions....In spite of rumors, all authors are not wealthy and if a reply is requested, by all means include a SASE....Also, if you are as poor a freehand writer as I am, PLEASE PRINT....I go crazy trying to decipher some of the letters I receive....Sometimes I can't even figure out the address. This type of mail ends up in my "round file".

I have recieved some minor criticism that I possibly don't go into enough detail on the mechanical layout of a device I describe....I am willing to make a bet that I can give 10 experienced experimenters the same circuit to build and when finished, they would all work, but you would never recognize them as being built to the same circuit if they were placed side by side....This is the "name of the game" since parts can be scrounged for the junk box, pirated from a defunct equipment, purchased, etc., and with a little home-brew genius thrown in, the final cosmetic appearance dosn't matter if it works....I will however go into detail on any device I describe if required for proper performance.

To get to the "nitty grit", we do have one major problem on the low frequencies and it concerns the high noise level encountered in reception in most urban and suburban areas....After all, if you can't hear them, you can't log or communicate with them....Unfortunately it is man-made noise.

Atmospheric static is bothersome and even effects the higher frequencies, but this type of intermittent interference can be greatly reduced by using the receivers noise blanker....However the noise generated by many household, industrial and medical appliances produces a "buzz-saw" hash that is impossible to eliminate with even the best noise blankers....If you removed the noise spikes, there would be nothing left of the intelligence you wish to receive !

Therefor the receiving antenna should deserve considerable thought as to type, size and location since most of this noise is picked up by the antenna and I go into some detail on this in the Antenna Chapter and suggest that a study of this chapter should be made.

Regardless of what a device is called, if it radiates electromagnetic energy (Radio) it is a transmitter....Therefor we can consider these devices an unlicensed transmitter that is covered in the FCC Rules

Section 15....In this section the FCC clearly states that any unlicensed transmitter that causes interference to the reception of any authorized radio station has to cease operation until the interference has been eliminated....(Section 15.103).

Probably the most common offender is the cheap SCR Light Dimmers. Chances are that one of these installed in a household could destroy LF reception in a neighborhood area....Since it dosn't bother the FM and TV stations, who gives a "golly darn" ?....The owner is unaware of the problem as well as the electrician who installed same, and the manufacturers could'nt care less and I wonder if the have FCC "Type Approval"....Hi !

Basically the FCC Rules are on our side, but what can you do about it as far as eliminating a source of interference ?....First, you have to pin-point the source and what the device is....If the owner of the device refuses to co-operate in any reasonable manner, your only other course is to contact the FCC and explain your problem in a clear and intelligent manner....Be sure to include name and address of the owner of the device and what it is....The next step is up to the FCC's field office....You should get satisfaction within a reasonable time and if not, keep the needle in !.....The FCC's Washington, DC zip code is 20554....However you may get quicker results by looking up their nearest field office in your local telephone directory.

Since publishing the 3rd edition of my scrapbook, the Morris Coil Winder is no longer manufactured....While I am still getting good service out of my 8 year old machine, I decided to build my own from scratch and it does produce a very respectable duo-lateral winding. I describe the machine in the Coil Winding Chapter and I might add, that I used nothing more sophisticated than a drill press in making all necessary parts.

This edition will not go into much detail on surplus equipment conversion since the availability of same is very spotty and not very dependable as to quantity.

I sincerely hope the following text will permit the average LF Buff to enjoy the best in receiving and transmitting pleasures and keep the soldering iron hot.

POTPOURRI, GIMMICKS, ETC.

In the following text, for circuit parts other than common resistors and capacitors, I will refer to a Radio Shack (or other source) part number....However, any well stocked radio emporium should be able to supply an equal part.

In all circuit diagrams the following part values are used:-

Resistors

Unless noted otherwise they are standard carbon types of 1/4 to 1/2 watt rating....In the case of potentiometers, again carbon type.

Plain numbers are OHMS.
Followed by a K, add 1000 to the number.
Followed by an M indicates MEGOHMS.

Capacitors

Numbers from 1 to 999 indicate PICOFARADS (pf).
Numbers preceded with a decimal point are in MICROFARADS (mfd).
Numbers followed by mfd are in MICROFARADS and polarity +/- will be indicated.

For the average by-pass and coupling service, common disc ceramics are satisfactory.

In frequency determining circuits such as a variable frequency oscillator, high stability types such as silver mica, metalized film and other recommended types should be used.

In any case, the voltage rating of any capacitor should be sufficient to provide a safety factor for the circuit it is used in....Normally, a 35 volt minimum working voltage should be satisfactory.

Inductances

In MILLIHENRIES (mh) unless noted otherwise.

In some cases I refer to IMPEDANCE....Hi Z is high impedance and Lo Z is low impedance....I may also refer, in the case of a transformer, to the resistance of the windings such as a 1 K primary and a 8 ohm secondary.

In my various experimental construction projects, I have run into many minor, yet irritating problems and have developed cures for same that I will pass on for what they are worth.

First, never trust your memory....Many parts, particularly capacitors have weird markings on same that you can remember when purchased, but can you recall the value 3 months later ?....Also when winding coils can you find the scrap of paper that you noted the turns on, taps, etc. ?....I use a bottle of white "Liquid Paper" typewriter correction fluid....It comes in a small bottle with a brush and a thinner is also available....I paint a patch of white on the part and when dry, mark the value thereon with a "Pilot Razor Point" pen....I then coat the identification with clear finger nail enamel to insure permanence.

I also find this system most helpful in marking circuit boards for socket and terminal designations.

The circuit board used for constructing a device should receive some practical consideration....For solid-state circuitry, considering the small size of the parts and minimal space requirements, a bread-board is a "forget-it".....For a one shot deal, I can't see the time, effort and cost of preparing a printed circuit board, particularly if it may be necessary to make minor circuit changes....I have settled on using the common perforated boards such as the phenolic boards with 3/32" dia. holes spaced @ .100 x .100....This spacing will accept most of your printed circuit components and when finished, the board can be mounted in an attractive cabinet.

I also always use sockets for all my transistors and IC's....Solid state devices don't like high heat and if heat sinks and proper soldering techniques are not used, you can ruin the device....Also, a socket makes replacement and substitution easy.

When using 14 pin IC's, I often use a IC socket adapter and mount the socket thereon....I normally use the Radio Shack 16 pin type (276-024) and find that I can normally mount about 90% of the associated parts on the adapter board....The extra two PC tabs allow for extra part mounting if necessary.

I find that the use of mini - jumper cables extremely useful in making temorary connections in experimental circuits....Radio Shack offers ten 14" long cables with mini-clips in 5 color coded pairs (278-1156). You can also make your own by using their insulated mini-clips (270-378).

When working with mini-parts and making solder connections, I often resort to a 3rd or 4th hand device....These are available commercially but I made my own....I mounted a flat, spring type of paper clip on a pedestal with a weighted base about 4" high....Using another weighted base, I used a piece of heavy gauge copper wire and mounted an alligator clip on the end....The copper wire should be soft drawn or a length of very small diameter copper tubing can be used....Using these two devices, it is simple to mount the necessary parts to be soldered and positioned so that you can hold the solder in one hand and the iron in the other and make a perfect connection.

When using co-axial cable to connect any RF circuitry, such as between a transmitter exciter and the final amplifier, antenna to a receiver, pre-amps to converters, converters to receivers, etc., beware the use of the cheap audio patch cords with non-soldered connectors....The quality of the cable is questionable and not worth the few cents involved....If necessary, make your own using solder type connectors and be sure that the cable you buy has a copper or tinned copper type of shield....There is a lot of cable floating around that has an aluminum alloy shield that will not accept normal soldering methods that are used for the cheap quick crimp assembly process and they are not worth a "golly darn" exposed to weather.

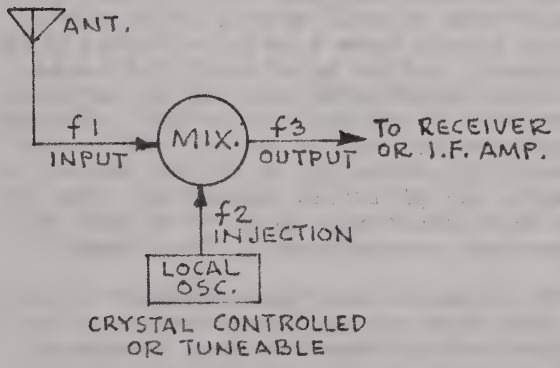
RECEPTION

As I mention in the introduction, the reception of weak signals on the lower frequencies can be a problem due to radio frequency interference (RFI) that can vary from neighborhood to neighborhood, time to time and day to day....A good receiving set-up tuned to perfection will only reproduce what its antenna system picks up....Therefor considerable thought should be given to the type and location of the receiving antenna and suggest that a thorough review of my antenna chapter be made.

There are many types of commercial receivers available on the market today that include the lower frequency range and quite a few command a respectable price....I have yet to hear any so-called all-wave receiver that will offer performance on the lower frequencies equal to a converter working into a respectable communications receiver.

Since the low frequency range can be considered 500 to 10 kHz, we are only dealing with a 500 kHz slice of the spectrum and even a Ham Band only receiver can be used with a simple converter to cover this range....When using a receiver with a converter, it is desirable to use the receivers most sensitive tuning range and the amateur 3500 to 4000 kHz band is desireable since amateur stations are relatively low powered and there are no high powered broadcast stations operating in this range.

To fully appreciate how a converter works, one must understand the simple "heterodyne logic" involved....A simple converter consists of nothing more than a Mixer and a Local Oscillator....The received signal frequency (f1) is fed into the mixer from the antenna input circuit....The local oscillator frequency (f2) is also fed into the mixer....The output frequency (f3) from the mixer is now (f1) + or - (f2) and the output circuit should be resonant at this new frequency. The tuning range of the receiver, of course, is (f3)....If the local oscillator is crystal controlled, tuning through a desired range is done by the associated receiver....A fixed frequency receiver can be used, however in this case the local oscillator has to be tuneable through the desired range....See Fig. 4-1 for "Heterodyne Logic".



Heterodyne Logic

f3 = f1 +/- f2

f2 = f1 +/- f3

Fig. 4-1

So let us consider a converter design....I have tried many circuits using both untuned and tuned input arrangements and the improvement in sensitivity using a tuned input was well worth the effort of providing coils and tuning capacitor to cover the 500 to 5 kHz range that I desired.

Providing a tuneable circuit covering some 500 kHz in the LF to VLF range does present a problem....Whereas a 365 pf variable capacitor will tune a coil in the medium and high frequency range some 1000 to 2000 kHz, as you approach the low frequency end of the spectrum, only a few kHz....Therefor a 365 pf capacitor will require numerous coils to provide continuous coverage of 500 to 10 kHz, which is desireable for the average LF Buff....I offer suggestions on this problem in the Coil Winding Chapter.

Fig. 4-2 is a converter circuit with a tuneable "front end" that I feel is about as simple as you can find....It uses tried and proven circuits in the Mixer and Local Oscillator that are FET's....If you have a favorite crystal oscillator circuit, it can be substituted for the one I describe....The circuit as described is designed to be used with a receiver tuning the 3500 to 4000 kHz Ham Band....Using the 3500 kHz crystal, 10 kHz will come in on the receiver at 3510 and 500 kHz at 4000 kHz on the receivers dial.

Coil L2 is adjusted for best oscillator performance and Coil L3 is normally adjusted at mid-band on the receiver (3750 kHz) for general coverage, but for any particular portion of the band that the user is most interested in, L3 can be adjusted for "peak performance".

For C5, the Oscillator injection capacitor to the Mixer, I recommend a low value mica or ceramic trimmer capacitor with an adjustable range within 3 to 10 pf....Adjust this trimmer for best performance....The receiver coupling capacitor C6 is shown as 100 pf which is a target figure....If overloading on strong signals is encountered, this value can be reduced....A suggestion is to use a 50 to 150 mica trimmer.

Now we get to the tuned circuit L1/C1....The value of the tuning capacitor C1 should receive some thought as the higher value used, the less number of coils will be required....I suggest using a dual-gang variable found in most of your old tube type BC sets....With the stators connected in parallel, you should have a maximum capacity of some 700 pf....I use this arrangement, but as my circuit indicates, I also use frequency extending fixed capacitors that can be switched in across C1.....These capacitors that I use are 470 pf and .001 mfd. They are connected to a SPDT toggle switch with a center OFF position....Radio Shack #275-325 or equal....Actually, a rotary switch can also be used, and if you only use a 365 pf tuning capacitor, you can add a series of fixed capacitors that could add up to some 2000 pf, and in this case, the tuning capacitor now becomes a "fine-tuner".

Actually, the tuned circuit L1/C1 is not a very "sharp-tuned" circuit and the tuning while broad, it does increase the sensitivity of the converter and well worth the effort not to have too many frequency gaps in the resonant tuning range.

For the coils, you have two basic choices unless you go for some of the wide range tuning inductors that I describe in the Coil Winding Chapter....The first is to mount all your coils on the circuit board and use proper switching to select the desired tuning range....The second choice, that I prefer, is to use "plug-in" coils (Shade of yesteryears ?)....However, the plug-in coils I use have no similarity to the old large solenoid wound bakelite coils we used years ago....I mount my 1/4" slug tuned or "E" Core coils on the small 5 prong speaker plugs (Radio Shack 274-1210) using epoxy cement and mount the matching socket (Radio Shack 274-1212) on the circuit board....If you mount your converter in a fancy cabinet, the socket for the plug-in coil can be located on the rear apron or back-side....The use of plug-in coils while not as convenient as switchable coils, does provide the experimenter with certain flexibility that is desireable.

The 5 prongs will suit most desired coil and coupling configurations. A primary coil and a secondary coil with a tap, as required.

After completing the converter assembly, make your normal checks as to wiring accuracy, good solder connections, etc....Connect the converter to your receiver and tune the receiver to 3500 kHz that is the local oscillator crystal frequency....If you don't pick up a strong "beat note", adjust the slug in L2 until you do....Throw your power off and on and adjust the slug until you get the most dependable operation. The next step is to resonate the mixer output coil at mid-band on your receiver (3750 kHz)....For this step, a signal generator is most helpful....Connect the signal generator to the Gate of Q1 @ 3750 kHz and with your receiver set to the same frequency, adjust the slug in L3 for maximum signal strength....The next step is to check the front-end tuning (Antenna input)....It is assumed that all functions up to this point look okay !

The final step, is get the input circuits working and checked out. Here again, a signal generator is the best answer and it should be connected to the antenna input....I suggest starting at mid-band, some 250 kHz or so....With the proper coil, by tuning capacitor C1, you should get a decided improvement in signal strength when tuning through resonance....This proceedure can be followed through the range of the signal generator....Without the use of a signal generator, you can connect an antenna to the converter input and seek-out reasonably strong beacon stations....Most signal generators will not tune below 50 to 75 kHz....In this case, you have to rely on "peaking" the ambient noise level on the lower frequency range....If you don't get a decided "noise-level peak" at any frequency that the companion receiver is tuned to, something is wrong !....For the bottom end of the scale, you should be able to pick up the OMEGA Navigational stations that operate in the 10.2 to 13.6 kHz range....OMEGA transmits weird sounding and variable pitched "beeps" that are unmistakeable from the average RTTY or CW station.

With the converter in working condition, from here-on-in the quality of your reception will largely depend on the quality of the receiver it is used with and the type of antenna used and I also will go into detail on same as well as pre-amplifiers, etc. that can be used with this or any other converter.

Have fun !

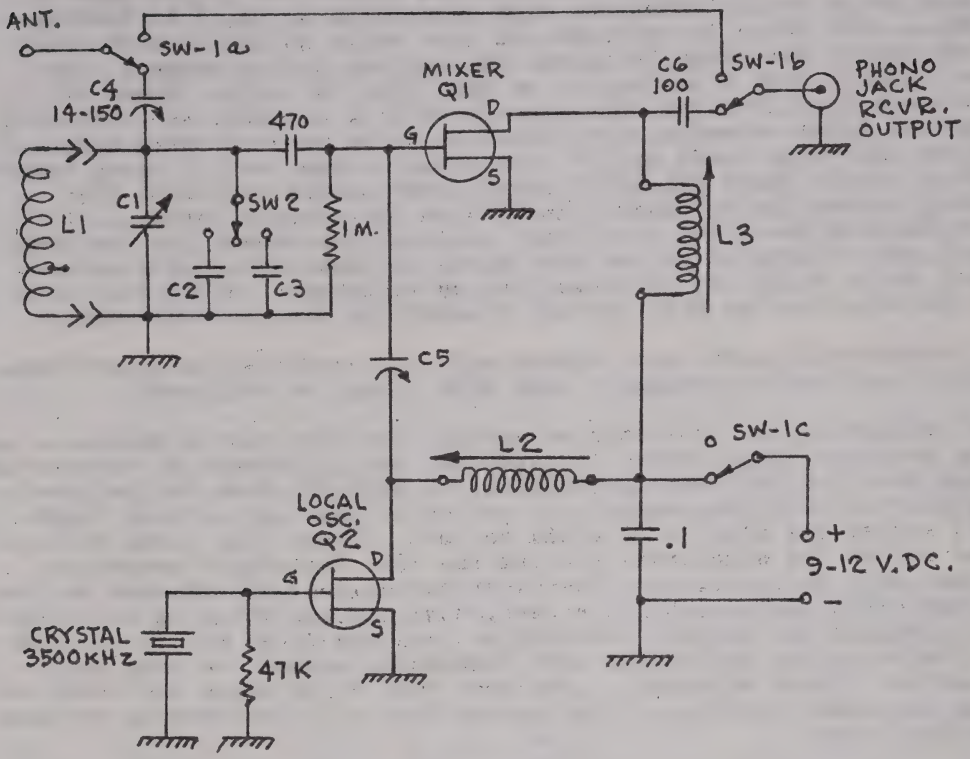


Fig. 4-2

Medium to low frequency converter

L1- See text and coil winding chapter.
L2 & L3- 90 turns of #32 enameled wire on 1/4" dia. slug tuned form....Depending on the permeability of the core material turns might have to be adjusted.
C1, C2 & C3- See text.
C4- Arco/Elmenco mica trimmer....Adjust for best performance....A fixed capacitor can be substituted by experimental evaluation.
C5- See text.
Q1 & Q2- Small signal general purpose FET....MPF102 or equal.
SW-1- 4 pole, 2 position rotary switch (3 poles used) for converter on/off and antenna by-pass to receiver (Radio Shack 275-1384).
SW-2- See text for frequency extending capacitors.

Note:- To eliminate fundamental signal feed through, the converter should be installed in a shielded metal enclosure....Good grounds should be common for both the converter and receiver. Use as short a piece of co-axial cable between the converter output and receiver input as possible.

REGENERATIVE PRE-AMPLIFIER

The word "regeneration" has practically been forgotten in this modern world of high frequency radio communications....Well, if I have my way it will become a very popular word among low frequency radio buffs.

Regeneration is the process of using feed-back in a detector or amplifying stage (tube or solid-state) through a smooth operating control to place the circuit on the threshold of oscillation....At this point the "Q" of the circuit is increased tremendously as well as the sensitivity and selectivity of the stage....You only have to hear a properly operating regenerative pre-amplifier to appreciate its value in picking weak signals out of the noise level.

Regeneration is a "natural" for the lower frequencies and many of the surplus WW-II TRF receivers used regeneration in the detector stage.

There are too many LOWFERS that have used regenerative pre-amplifiers with excellent results to question their value....In many cases it is a matter of being able to copy a signal or "forget it"....If you can build a converter, you can build the regenerative pre-amp to be described herein....The tuned circuits are similar except in this case, a source tap on coil L1 is necessary to obtain feed-back.

In my Addendum '77/'78, I describe a similar device....I fooled with regenerative amplifiers for some time and finally, with a few modifcations, offer the circuit as shown in Fig. 4-3.

The coil L1 and capacitors C1, C2 & C3 are the same as shown for the converter Fig. 4-2, except a tap on the coil L1 is required that is located 1/4 to 1/3rd the number of turns up from the grounded end.

The secret of success with any regenerative circuit is a smooth control of the feed-back circuit particularly at the threshold of oscillation....In this case, it is accomplished by the use of two 10K potentiometers....R1 is connected across the coils source tap to ground....The rotary slider is connected to a 10K potentiometer that is also in series with a 2K resistor to the source of the FET....R2 is connected as a variable resistor....In operation, R2 is set at approx. 3/4 resistance value....R1 is now adjusted to the point where the circuit breaks into oscillation....R2 is now backed-off and is used to provide the best threshold setting for reception....It may be necessary to repeat this process for each coil used, but once the operator becomes familiar with the operational circuit, the adjustments of the controls becomes, second nature.

The antenna input capacitors C4 & C5 are optimum for general use, but if you have a special range that you wish to optimize, I suggest that you experiment with various capacitor ratios to obtain best performance.

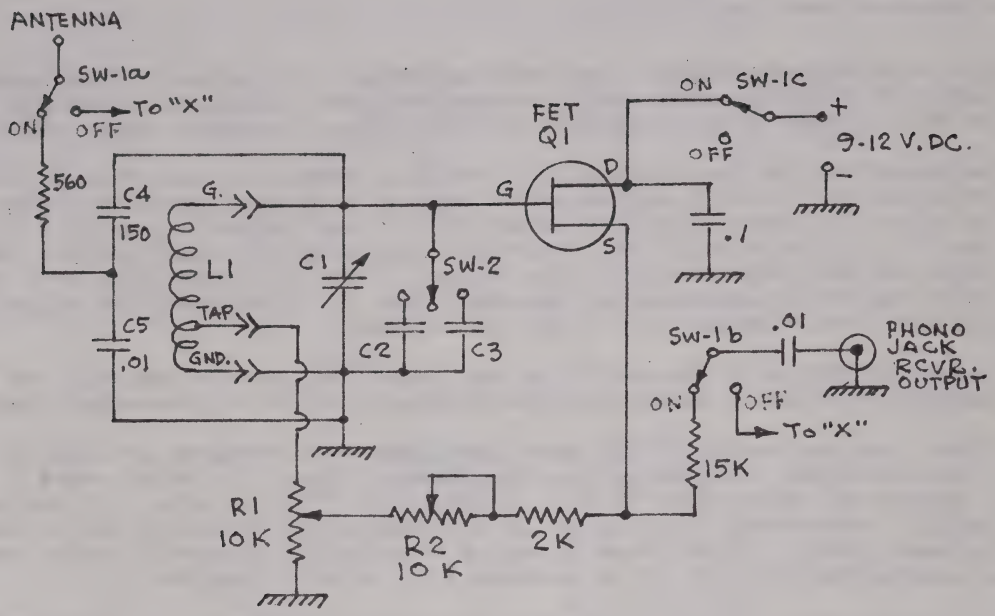


Fig. 4-3

Regenerative Pre-amplifier

L1 - See text.
C1, C2, C3 - Tuning and frequency extending capacitors, see text.
C4, C5 - See text.
R1 - Regeneration coarse set.
R2 - Regenearation fine tune for threshold desired.
Q1 - Small signal general purpose FET....MPF102 or equal.

Note:- For best performance, solid, rigid construction should be used. A shielded enclosure is desireable but not as necessary as in the case of a converter....Again, common and good grounds should be used connecting the pre-amp and converter/receiver and co-ax cable should be used for the pre-amp output.

SW-1 is the same type of rotary switch that I describe for the converter....In this case when the switch is in "off" position it will transfer the antenna to the receiving system....It is a handy device since by throwing the switch from off to on, it will give you a good idea on the pre-amplifiers performance.

THE FERRANTI ZN414

NOTE:- The following article on the ZN414 should not be considered as offering the design on an efficient communications receiver for the low and medium frequency range, but as a very simple and effective device that can be used for many purposes such as a monitor, remote field strength meter and a very simple receiver that can be used for tracing down noise sources in your neighborhood....It could also be considered for a fixed frequency or tuneable IF amplifier with audio output for use with a converter....I am sure that any real radio experimenter can have a lot of fun fooling with this device.

I first became aware of the ZN414 in articles published in the June 1974 issue of Popular Electronics magazine....I obtained several of the devices and played around with them for some time, and felt that they offered sufficient merit for reception in the low and medium frequency range, I mentioned the availability of same in the 3rd edition of my scrapbook series.

The ZN414 comes in a tiny TO-18 package with 3 leads....It is claimed that it contains the equivalent of 10 transistors....Circuit data supplied indicates a very high input impedance (most desireable), 3 stages of RF amplification, detector and an extremely effective AGC system....With only 1-1/2 volt dc supply, earphone volume is obtained with less than 1 ma drain.

Typical gain of 72 db over a frequency range of 150 to 3000 kHz is claimed, but my experiences indicate that this range is quite conservative....AGC range is 20 db and output, 30mV rms....These are claimed to be typical, not maximum.

Before the preparation of the text for this 4th edition, I decided to re-familiarize myself with the device and had some bread-board fun....I used Ferranti's recommended circuit and tried the device out on the AM BC Band using a standard loopstick antenna and a 365 pf variable capacitor....Since my shack is in the basement, I did not get any startling results....I wound a small coil and connected same in series between my 50 ft. vertical antenna and ground and then coupled same to the loopstick antenna and the results were quite surprising....With a simple TRF circuit, you may expect a jumble of BC stations that are hard to separate....Not in this case, the AGC system seemed to "lock in" on each station as I tuned, and I noticed a very minimal amount of adjacent channel interference.

Using a single tuned circuit in the lower frequencies below the BC Band, performance fell off and I had to go to a double tuned circuit and I also added a 5000 ohm potentiometer in the voltage plus (+) lead to provide a better control on the AGC action....For 160 to 190 kHz, I had some Miller #9013 coils (Tap not used) and had no trouble tuning "TUK" @ 194 kHz, with resonable volume.

Depending on the setting of the 5K pot. current drain runs between 0.2 to 0.6 ma....When a signal is tuned in, the current will rise making the use of a 1 ma. meter useable for an "S" meter.

The Ferranti ZN414, cont'd.

When the ZN414 is used in the normal manner, it is only capable of receiving AM signals....In able to copy CW or DSB and SSB voice transmitters, it is necessary to apply an external signal source using a signal generator or a VFO tuned to the received stations frequency. While this can be accomplished by using "front-end" injection, I did not like the inconvenience and decided to see if I could make the circuit regenerative....After some experimental endeavours, I found that if I added a 3 to 4 turn loop of insulated flexible wire between Pin #3 and its return to ground, and coupling this loop to L3, I did obtain the necessary feed back to obtain regeneration and CW signals could now be received....In other words, a beat note could be heard when tuning through a signal....Proper positioning of this coupling and adjustment of the AGC control potentiometer R1 will provide a very satisfactory performing device.

The circuit I used is shown in Fig. 4-4....For information on the ZN414 contact Ferranti Electric Inc., 87 Modular Ave., Commack, NY 11725....I also understand that CKT Specialists, Tempe, AZ 85281 also sell the devices.

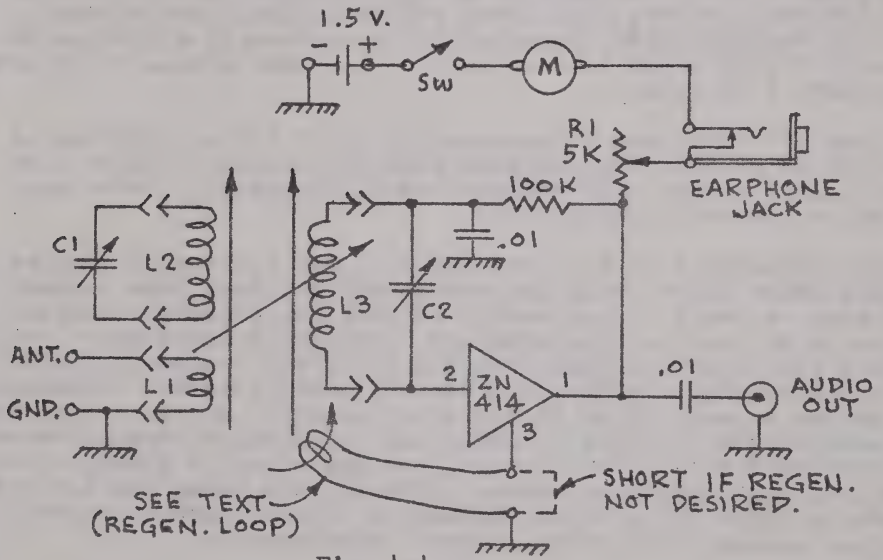


Fig. 4-4

Note:- All coils wound on 1/4" slug tuned forms with #32 en. wire.

L1 - BC Band - 30 turns.....160 to 190 kHz - 150 turns.
L2 - BC Band - Not used.....160 to 190 kHz - 300 turns.
L3 - BC Band - Std. Loopstick.....160 to 190 kHz - 300 turns.
C1, C2 - 365 pf variable capacitors.
M - 1 ma. meter used for measuring signal strength.
See the coil winding chapter for additional information on coils.

THE PALOMAR VLF CONVERTER

The Palomar converter has been on the market for quite a few years and the use of same has been enjoyed by many low frequency radio enthusiasts....The quality of construction and it's ease to use, as well as a reasonable "price tag", makes it an easy way to be able to tune in on the low frequency spectrum from 500 kHz to below 10 kHz when used with a receiver capable of tuning 3500 to 4000 kHz.

The following is NOT INTENDED to criticize a fine product, but only a means of suggesting ways to improve the performance and flexibility of the converter.

The converter does not use a tuned input circuit and its sensitivity can be greatly improved by the use of a tuned circuit between the antenna and the antenna input to the converter....Yes, this requires coils and variable capacitors (or wide range tuned circuits that I describe in the Coil Winding Chapter) but the effort is worth it if you want maximum performance....See Fig. 4-5 for a suggested tuner.

Being an experimenter, I can't keep my "cotten picking fingers" off any device I have a chance to fool with and I got thinking about if the converter could be modified to use an external VFO in lieu of the crystal and also the substitution of other frequency crystals in case I wished to use the converter with a companion receiver that tuned another range, other than 3500 to 4000 kHz....MY THINKING, was to be able to use the converter with my AM car radio for monitoring my signals and check potential areas for best LF probogation....It appeared obvious that the internal 3500 kHz crystal would have to be removed and external means for using same be made in the converter housing.

I removed the bottom cover (4 screws in the corners) and this exposed the PC board....The crystal appeared to be a HC33/U type and it was soldered into the PC board and held in place with a "gob" of plastic cement....I carefully removed the crystal and "patched in" a 1600 kHz crystal and was pleased to find that it worked okay and I could now use it with my car AM radio....The next endeavour was to see if I could substitute a simple L/C circuit in lieu of the crystal for VFO tuning....I tried and it worked !....My next problem was how to install an external crystal socket in the converter housing, as I mention above....It appeared that the PC board was held in place by two screws in the top cover and by removing same it released the board without disturbing any lead wires or solder connections and there is sufficient "play" in the wires to permit access to both sides of the PC board....I studied the situation and found that there was sufficient space between the top of the PC board and the converter cover to install a low profile HC6/U crystal socket on top of the PC board and by flattening the solder terminals on the socket, I could pick up and solder same to the original crystal solder terminals....The only major problem in this project is that two holes have to be drilled in the top-side of the case to suit the new crystal socket profile and I used the existing bolt holes as a template for same....Be sure to note the ground side of the crystal socket for future reference if the converter is used with an external VFO....With care, when installing the new crystal socket, the finished appearance can look quite professional.

The Palomar Converter, cont'd.

When the Palomar converter is used with an AM Broadcast receiver, there is always a problem of fundamental feed through....Most car radios are well shielded and if proper grounding and short lengths of co-axial cable between the converter and car radio is used, you can expect reasonable performance....However, the BC radio can be tuned to a clear channel and the VFO adapter can be used to eliminate fundamental signal feed through....Fig. 4-6 is a circuit of the VFO circuit and Fig. 4-7 is a suggestion for the co-axial cable connector between the VFO and the crystal socket.

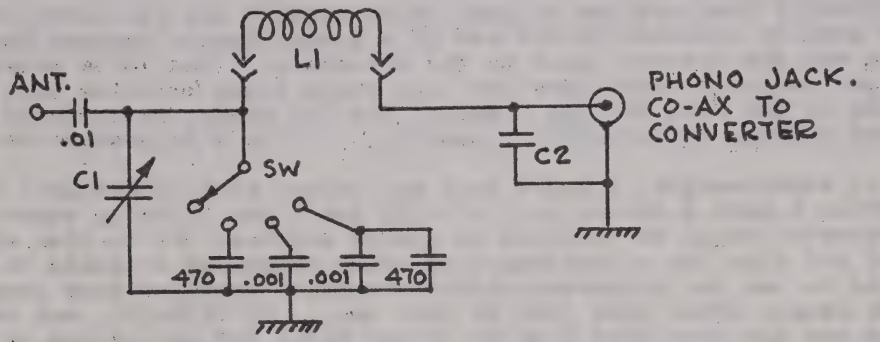


Fig. 4-5

C1 - Dual gang BC receiver variable capacitor (stators in parallel).
SW - Rotary switch used with frequency extending capacitors.
C2 - Suggest .02 to .04 mfd....Experiment for best results.
L1 - Target value for inductances:-

5 - 11 kHz, 0.28 h	50 - 100 kHz, 3.5 mh
10 - 20 kHz, 100 mh	90 - 200 kHz, 1 mh
18 - 38 kHz, 25 mh	150 - 350 kHz, 350 uh
30 - 70 kHz, 10 mh	250 - 550 kHz, 120 uh

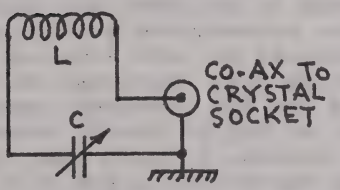


Fig. 4-6

L/C circuit to be resonant thru desired tuning range.

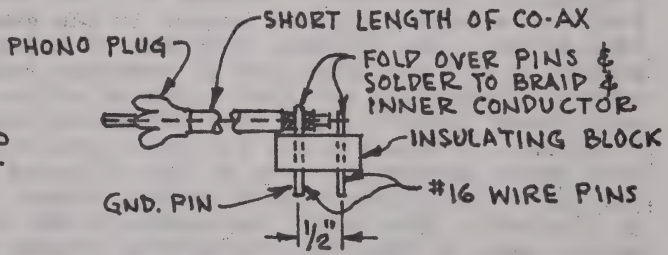


Fig. 4-7

Suggested connector

MORE ON THE BC-453/R-23 RECEIVER

I still receive correspondence regarding these receivers requesting information and help in making a tube substitution for the 12K8 that is used in the converter stage (mixer/local oscillator) due to my comments in my scrapbook....A converter stage is not a "gain" device and should not be a noise generator....I definitely recommend that this tube be replaced preferably a dual triode or a triode-pentode tube type.

First, the heater supply circuit should be rewired so that the tubes are all in parallel across the heater supply buss to ground....This eliminates any problem with tube substitution, as you can use all 6.3 or 12.6 volt tubes....The existing wiring had the tubes paired in series and would require shunts or series resistors involved in the heater circuits if all tubes did not have the same current drain.

So, lets assume that change has been made.

I personally prefer 6.3 volt heaters as it offers a larger choice for tube substitution....I replaced the 12SK7's with 6AC7's in the RF and IF stages with noticeable improvement in gain.

For the converter stage you have a choice of either a dual triode or a tride-pentode....I've tried them all and my favorite is a dual-triode (6J6) but the comparisons were minimal in performance....While an adaptor can be used for the tube substitution, I suggest that the octal socket for the 12K8 be removed....Disconnect the wires and mark them with some kind of stick-um tape with the pin number noted thereon. Cut a piece of sheet metal that will cover the octal socket hole and mount the new socket in same....Re-wiring can now be made....See Fig. 4-8 for socket change and tube substitution.

The IF transformers in this set have an adjustment for varying the coupling between the primary and secondary coils....By removing the srew caps on top of the cans this will expose the trimmer capacitors and you will notice a small plastic rod extending thru the center hub. Use a pair of pliers and pull the rod carefully up and this will increase the coupling between the coils and increase the selectivity of the IF stages....Re-peak the trimmers for best sensitivity.

I also suggest that all of the bath-tub capacitors be removed and be replaced with disc ceramic or modern types....Also, please note that most grounds are made to solder lugs fastened to the chassis with small macine bolts....Check all grounds for corrosion and be sure that all grounds are secure.

To improve the receivers performance in regard to selecting upper or lower sidebands on a received signal, install a small (35 pf) variable capacitor across the BFO coil....With this capacitor at mid-point, tune in a signal for maximum strength and then retune the BFO coil by the screw driver adjustment to zero beat the signal....You can now use this new capacitor to favor the upper or lower sideband on a CW or suppressed carrier voice signal (DSB or SSB).

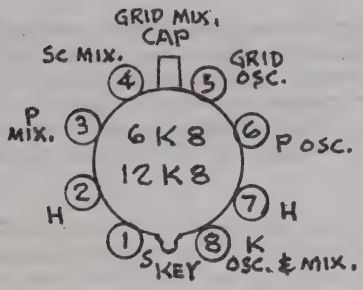


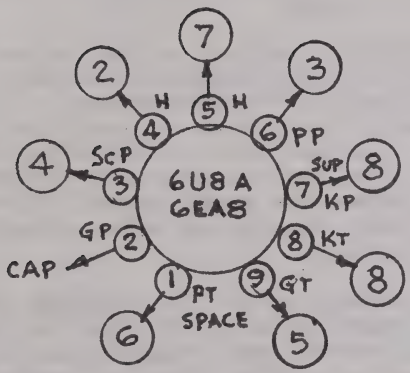
Fig. 4-8

Showing tube pin locations for tube substitution.

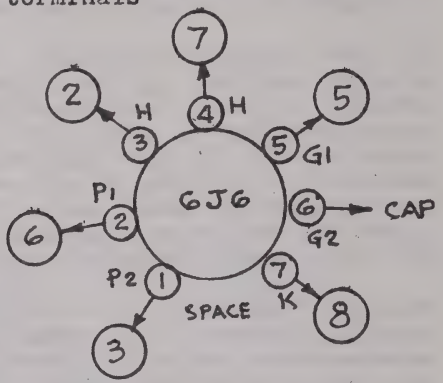
All views are bottom of socket.

Existing tube arrangement

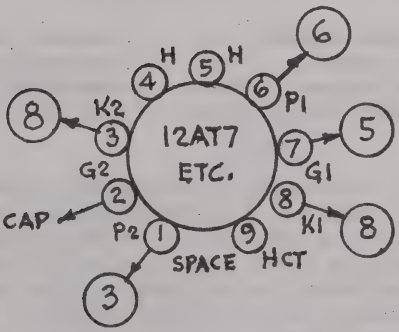
Note:- Outer numbers are existing tube socket terminals



For 6.3 vac Heaters



For 6.3 vac Heaters



For 6.3 vac, short pins 4 & 5 and connect to pin 2*. Pin 9 goes to pin 7*.

For 12.6 vac connect pin 4 to pin 2* and pin 5 to pin 7*. Do not use pin 9.

* indicates original socket terminal numbers.

Note:- in some cases, a very small capacitor (2 - 7 pf) may be required between the osc. plate and the mixer grid.

RYCOM 2174A RECEIVER MODIFICATIONS

In early 1978, I purchased a RYCOM 2174A receiver and made some modifications that I described in the August '78 issue of the LOWDOWN. I was quite surprised at the amount of mail I received concerning the article and have to assume that there are quite a few of these and similar sets floating around.

The official designation for the 2174A is a Frequency Selective Voltmeter....While it can be used as-is for a receiver, it was not primarily designed for this service....The frequency range from practically 0 to 420 kHz makes it most attractive to a low frequency radio buff....It is extremely well built and shielded and is self-contained with a 120 vac power supply, speaker and signal strength meter....It provides three selectivity positions of 100 Hz, 3 kHz & 10 kHz as well as selectable upper and lower sidebands and AM.

The receiver lacked sensitivity with most any antenna I used it with and a study of the circuit diagram indicated that the attenuating pads, etc. between the antenna input and the grid of the isolation amplifier (V1) had to go....I decided that I would convert the isolation amplifier (V1) to act as an untuned RF amplifier....This would permit the use of antenna tuners, pre-amplifiers, loops, etc...The first thing however that should be checked when examining your set is to be sure that all your ground connections are resistance-free. They used solder lugs rivited to the aluminum chassis and in some cases thru aging and corrosion they can become a poor ground....The following modifications can be made, step-by-step:-

1) Remove the receiver from its cabinet....Remove the shields over the two front panel switches (2 screws) which are the Antenna 135 & 600 ohm Bridge, BAL & UNBAL switch and the Attenuator switch...Remove the switches and associated parts as they will no longer be required, and also remove the wiring to the front and rear antenna inputs.

2) Remove the existing parts from the cathode (pin 2) of V1 to ground.

3) Remove the front and rear antenna co-ax connectors and replace without the insulating grommets....You can also replace with your own favorite type of connector....If you don't wish the choice of having the convenience of both a front and rear antenna connector, either one can be eliminated.

4) Install a .01 mfd capacitor between the antenna input to pin #1 on the low pass filter....Pin #2 of the filter is grounded....Connect the filter output, Pin #5 to the grid of V1 (pin 1), thru the existing 680 ohm resistor and its bypass capacitor.

5) Install a 5K potentiometer in the lower unused panel hole and wire it up between the cathode (pin 2) of V1 and ground and this should be by-passed with a .1 mfd. capacitor....This potentiometer will now act as an RF Gain control.

Fig. 4-9 is a circuit diagram for the above changes.

Rycom 2174A Receiver, cont'd.

With these changes, the signal strength meter is too sensitive and most signals will "pin" the meter....The only existing way to reduce the meter sensitivity is to back off on the CAL 2 LEV control, that actually appears to be the IF gain control and this reduces the audio output level that is not desireable....I put another 5K potentiometer in the unused upper switch hole in the front panel and connected this across the meter to be able to set its sensitivity at any desired level....I might mention that when running signal strength comparisons that the CAL 2 LEV control and the new meter sensitivity and RF gain controls should not be touched....See Fig. 4-10 for meter control.

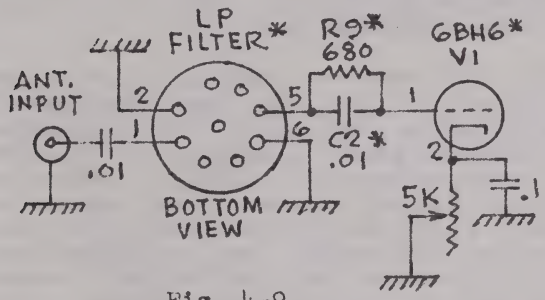


Fig. 4-9

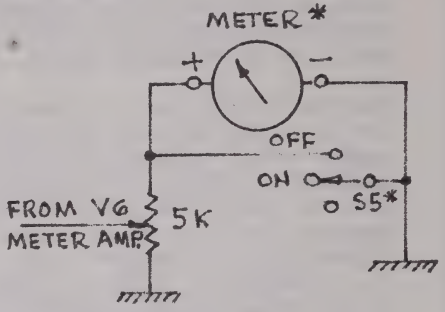


Fig. 4-10

Note:- * indicates existing part

After making the modifications, I consider the 2174A a very respectable receiver, particularly when used with an antenna tuner....I also have had excellent results using same with various loop and active antennas.

For reception purposes, the CAL 1 LEV potentiometer (lower left, front panel) and the calibrate oscillator V7 (12AU7) are not required...This space can be used for a noise blanker or a crystal calibrator....See any good radio handbook for suggestions.

Too conclude, I cut a piece of glossy cardboard of suitable size to mask-out all existing lettering for the lower left hand side of the front panel with holes to pass the controls....I painted same with a matching grey that complemented the panel....I then neatly lettered the new control functions and cemented same into place using rubber cement....The finished appearance is quite professional.

Final comment....Since finishing this article, I have noticed several other types of low frequency voltmeters offered on the surplus market that the basic modifications described in this article on the 2174A might be applicable ?

Broadband Pre-amplifier

Is your receiver tired, needs vitamins, a shot in the arm ?....Or possibly you have a sophisticated all-wave receiver that appears to "drop dead" in the lower frequency range ???....Then this simple pre-amplifier might be the answer to your problems.

It uses a recent new-comer to the solid-state field and called a VMOS. Basically, a VMOS is a high powered FET....I became familiar with the devices while searching for an efficient solid-state final amplifier for my 160 to 190 kHz transmitter and will describe the use of same in the Transmitting Chapter.

I also found that these devices were useable in active antenna systems that I will describe in the Antenna Chapter.

Using a device capable of dissipating 1 to 15 watts for a receiver pre-amp might sound ridiculous, all I can say is that any device that will give me a good signal strength gain with low noise, should be appreciated.

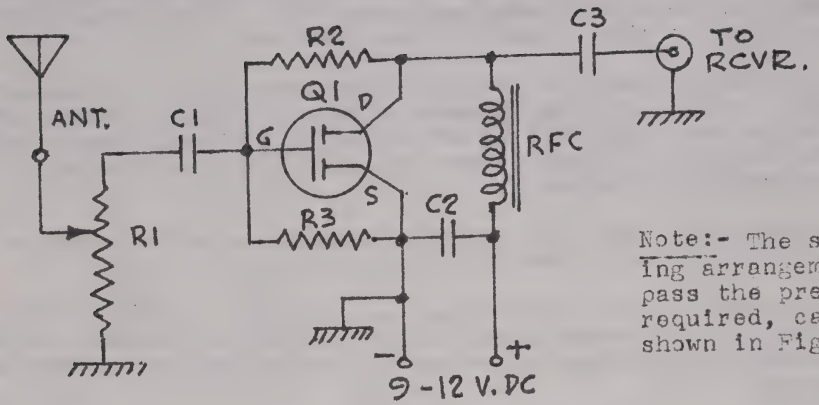
The only VMOS's that I have experimented with are the VN10KM, VN40AF, VN66AF, VN67AF and the VN88AF....I notice that in my latest Radio Shack catalog, that they list the VN10KM and the VN67AF as part nos. 276-2070 & 276-2071 respectively....In all cases, I never used more than 5 to 12 volts on the pre-amplifier and found that the VN10KM considering price and current drain fullfilled my objective....For continuous use however, I do not recommend that the VMOS pre-amp be used with dry cell batteries due to the current drain.

Since no tuning is required, the circuit is the utmost in simplicity and very effective in the VLF to HF range....Due to the terrific gain of the VMOS, a large antenna with sizeable aperture may overload the VMOS, therefor, I use a 5 to 10 K carbon potentiometer across the VMOS input to ground....The antenna connection goes to the center arm. This potentiometer can also be used as a "gain control"....For a constructor that may wish to eliminate the potentiometer, I suggest that a variable capacitor be used in series with the antenna to the input of the pre-amplifier, however a potentiometer is cheaper than a good variable capacitor.

Fancy construction is not required and I mounted mine on a small perforated board (2"x3")....The pre-amp could even be installed within a receiver cabinet due to the small size and power obtained from the existing power source if available....For sets with vacuum tubes, a simple rectifier circuit could also be included to power the pre-amp from the heater ac supply.

The RF choke in the Drain supply should be good inductance-wise in the lowest frequency range you wish the pre-amp to be operational. I used a small "E" core, bobbin assembly with some 300 turns of #32 enameled wire on the bobbin and it appears satisfactory below 10 kHz.

The circuit diagram is shown in Fig. 4-11.



Note:- The same switching arrangement, to bypass the pre-amp if not required, can be used as shown in Figs. 4-2 & 4-3

Fig. 4-11
VMOS Receiver Pre-Amp

C1- .001 mfd.
C2- 1 mfd.
C3- .01 mfd.
R1- 5 to 10 K carbon potentiometer.
R2- 4.7 meg.
R3- 2.2 meg.
Q1- VN10KM VMOS....I have used other types of VMOS's in this circuit and considering costs and power drain, I can detect only marginal differences in operation.
RFC- This RF Choke should be effective down to the lowest frequency that the pre-amp is desired to tune.

I have found that this pre-amplifier very effective on the lower frequency radio amateur bands, 160, 80 and 40 meters.

LOW PASS FILTER

Depending on your location and receiver selectivity, Broadcast Band station feed through can be a problem with many converter/receiver assemblies....If it is only one station, a wave trap can help reduce this problem (next subject on the agenda), otherwise you should consider a Low Pass Filter.....A simple filter is shown in Fig. 4-12. Additional sections can be added for improved performance....A slug-tuned coil is suggested for the filter and experiment with inductance values to provide the best "cut-off" frequency.

To be effective, the filter should be installed in a shielded enclosure such as an aluminum mini-box with co-ax cable fittings in & out of filter....Good grounding is necessary.

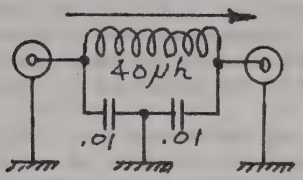


Fig. 4-12

WAVE TRAPS

There is nothing new about a wave trap as they go back to the early days of radio....A wave trap when installed in an antenna will act as an insulator at it's resonant frequency since it is nothing more than a simple L/C circuit....Most of the amateur radio multi-band transmitting antennas (vertical and beams) use wave traps in their construction....When the antenna is tuned off the resonant frequency of the wave trap, it acts as nothing more than an additional L/C inductance in the antenna length.

The same principle used for transmitting antennas, can and has been used for reception interference by strong stations that are not operating on the same frequency that a receiver may be tuning to, and by the use of same, this interference can be eliminated.

The reasons why a low frequency radio buff should be plagued with a strong signal from a station that is not on the frequency he is tuned to, is to involved in heterodyne mathematics to be covered in this scrapbook....For want of a better word, they are called "images".

To get practical, since these "images" are received by the antenna, let us get rid of them via the antenna by the use of a wave trap that should be located as close as possible to the receiver....The frequency of the offending station has to be known, and a simple wave trap that is nothing more than a tuned L/C circuit that is resonant at the same frequency is installed, and "goodby" image.

The largest problem with images is caused by Broadcast Band stations. Also there is a good chance in the average area, that only one station may be causing the interference....In this case, any L/C combination that is resonant thru the BC Band can be used in a wave trap....I feel that the mounting of a wave trap for best performance should be in a shielded enclosure....The L/C circuit should not be grounded, as it is only used in series with the antenna feed line....A slug tuned coil with the slug adjustment available from outside the enclosure is ideal for tuning the trap to proper frequency....See Fig. 4-13

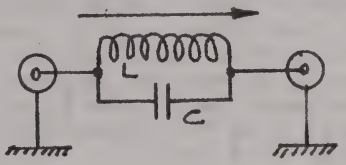


Fig. 4-13

The L/C circuit has to be resonant at the offending stations frequency....I suggest that a bread board set-up be made before enclosure.

ANTENNAS

This chapter will cover antennas used for reception in the low to medium frequency radio spectrum....Transmitting antennas for use on the nonlicensed communication bands, 160 to 190 kHz and 510 to 1600 kHz, will be covered in the Transmitting Chapter.

Receiving antennas can fall into many categories such as long wires, loops and short active antennas....While most any type of random wire can be hooked up to a receiver and it will work, performance will depend on the quality of the receiver and the neighborhood enviornment.

I am often asked as to what type of antenna is best and my answer is always the same....Use the one that will give you the best "signal to noise ratio" (S/N/R)....This is a basic fact that can't be disputed ! Unfortunately, there is no perfect antenna for all conditions that may be encountered in low frequency reception and many serious low frequency buffs and LOWFERS use two or three types to combat ambient noise and interfering signals, and use the type that offers the best S/N/R that can vary from hour to hour and day to day.

I wish that I could offer a "perfect antenna", but the problem is very simple (tho frustrating)....What works best for me, may not work best for you and this situation can vary from area to area.

My experimental endeavours has indicated an important point that the noise level encountered in the low frequency range is not tuneable. However, if the antenna can be resonated at a received stations frequency, it will favor the signal more than the noise and improve the S/N/R....Something to think about !

Unless you live in a very secluded area, away from neighbors, power lines, industrial and medical establishments, etc., a long wire antenna can be nothing more than a "noise collector", and the following pages will describe various type of antennas that should be given consideration.....As a matter of fact, I often use my 160 meter ham antenna (long wire) as a reference antenna for comparison purposes. 99% of the time, my loops or short active antennas will be better.

LOOP ANTENNAS

Loop antennas basically fall into two categories....The "box loop" or the "ferrite core" type....Both types exhibit the same receiving characteristic which is a "Figure 8" pattern....Maximum signal is received off the plane of the loops and they exhibit a sharp null in signal strength off the sides....This of course is a bi-directional pattern and the loop can be rotated to favor a wanted signal and also attenuate an unwanted signal or noise source.

It has always been a major mystery to me why Radio Hams don't use loops for reception on the lower frequency bands, namely 160, 80 and 40 meters....Beam antennas are commonplace for the higher frequency Ham bands 20 meters and higher, yet the size of beam antennas for the lower frequency bands are impractical for the average Ham, so why not use a small loop for reception ?....Believe me, I have used them and they really do a job !

In the earlier editions of my scrapbooks, I go into detail on the construction of open wire box type loops, but let us take another look at the subject....First, a box loop is nothing more than a large coil and a coil dosn't care if it is wound in a round, square or rectangular fashion as it is only the number of turns and the value of the tuning capacitor that will determine its resonant frequency....The larger the size will increase its aperture for collecting the electro-magnetic energy radiated from various transmitters.

The simplest support for a loop antenna is in a "Cross" configuration with suitable supports at the 4 corners to hold the wires....A stable base is used and means for rotating the loop is necessary. Since a loop is bi-directional, only a 90 degree rotation is needed. I recall an article where the author mentioned that he mounted his loop on a closet door near his operating position....I have used taps on a loop to increase its frequency coverage, but have noted that if carried to an extreme, the unused turns seem to saturate the loop and tuning becomes broad and the directional characteristics becomes impaired....I have also noted that for best performance, loops seem to like a high C to L ratio....I suggest using the highest value variable capacitor available and if necessary, frequency extending capacitors can be added as I describe for the converter and pre-amp in the Reception Chapter.

Due to variations in size and distributed capacity between the wire turns, it is difficult to give target values of wire turns for frequency and tuning capacitor....I suggest that an experimenter make up a frame, some 2 to 3 feet on a side and wind 10 turns of insulated wire on same....Use the largest value of tuning capacitor available and hook it up to your receiver....By tuning both the loop and the receiver, it will not take too long to get the feel of the number of turns required for a desired range....Keep notes, as they will be of value for future reference.

Another material useable for loop construction is the multi-conductor ribbon type cables used for computor hook-ups....They are available in a wide range of conductors....A necessary length, to suit your frame can be cut and the insulation stripped at wire ends and then they are soldered together (end to end) in stagger fashion so that you end up with a continuous wire loop....I notice this cable is offered in many surplus outlet adds.

An experimenter may also consider adding a tap or adding an additional loop (a few turns) for use with a regenerative pre-amplifier.

FERRITE CORE LOOP ANTENNAS

Most everyone is familiar with the small ferrite core loop antennas contained within the small transistor radios....Over the years, large diameter and long ferrite rods have become available at reasonable prices....Diameters from 3/8" to 1/2" and lengths from 7" to 8" have become very popular for use as a low frequency loop antenna....Permeabilities as high as 2000 are available....The cores are made from magnetic ferrites and have the ability to attract electro-magnetic radiation.

The length of the ferrite rod core will now determine the aperture of the antenna, not the diameter of the core or coil as in the case of a Box Loop....Ferrite rods can be cemented together and bundled with staggered joints to produce most any desired length core, but I suggest that an experimenter start off with a rod some 7" to 8" in length and the largest diameter available and fool with some coils and I suggest a review of my Coil Winding Chapter be made that will explain what permeability of a ferrite core is all about.

Normally, the coil is located at the center of the ferrite rods and with its associated variable tuning capacitor, the assembly for all practical purposes has to be located in close proximity to the receiving position....Also for full coverage of the LF to VLF spectrum coil changes of proper inductance will have to be made and this has to be considered in the construction of the ferrite rod loop.

For maximum performance, the loop assembly should be mounted on a altazimuth support similar to a land telescope or camera support for a tripod....This will permit the loop to be positioned in both the horizontal and vertical planes.

As an experimental endeavour, I have located a coil at the center of a wood strip and placed guides (with clamps) each side of the coil so I could slide in ferrite rods on each side of the coil....By varying the penetration of the rods into the coil, quite a wide frequency excursion was achieved and I feel that this idea is worth further experimentation.

So, to get again to the "nitty grit", if you live in a frame house and your receiving position is above ground level, you should have no problems in using any type of loop receiving antenna, however there may be many LF radio Buffs that don't have these conditions such as myself....I live in a stucco house and the first floor which is the living area is surrounded with wire mesh, and my shack is in the basement, therefor all my loop experiments are conducted in a semi-finished attic with an asphalt shingle roof....Using a loop that requires positioning and tuning so remote from my receiving position was a "forget it" !....However, some thinking solved part of my problem....I could use a small TV antenna rotator that would take care of turning and positioning of the loop....Now, how to achieve resonance?

My experiments with active antennas gave me a solution....Why not use an "Active Loop Antenna" ?....All I had to do was wind a Collecting Coil on the ferrite core and feed same to a Broad-Band Amplifier and using co-ax cable feed the output to a tuneable pre-amplifier that is located at the receiving position in the basement...The TV rotator would take care of the positioning....This set-up would only take care of the horizontal plane, but it was very effective.

Any readers that have a rotary TV antenna or Ham's that have rotary beam antennas, can use this system with minimum effort....The active antenna amplifier assembly will have to be enclosed in a weatherproof housing.

The following sketches are systems that I have used that provide satisfactory results:-

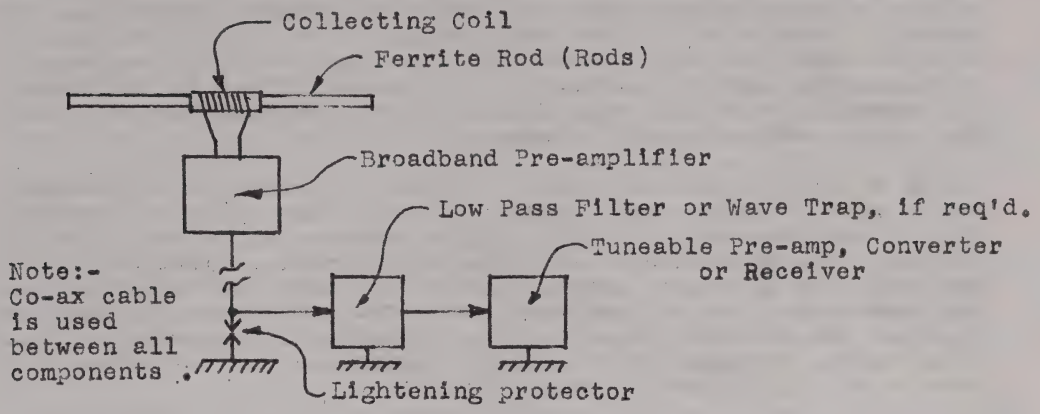


Fig. 4-14

General Arrangement

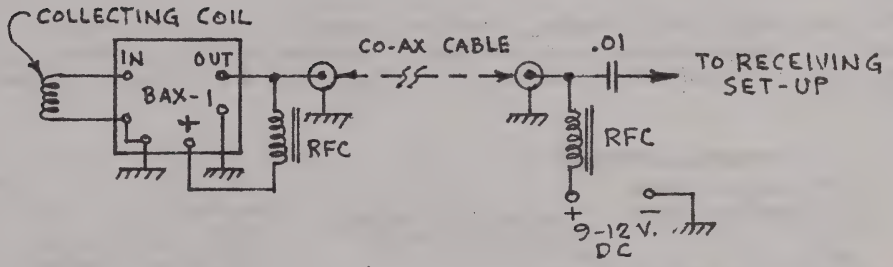
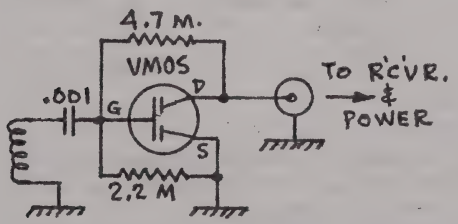


Fig. 4-15

In this case I used a commercially available broad band preamplifier as manufactured by International Crystal Mfg. Co., 10 North Lee, Oklahoma City, OK 73102....It is their BAX-1 and comes in a kit form. It is easy to assemble and makes a nice fit into a small mini-box, 2-3/4" x 2-1/8" x 1-5/8"(Radio Shack 270-235)....The RF Chokes should be effective at the lowest desired operational frequency.



Another pre-amplifier that I had good results with uses a VMOS....The VN10KM was an excellent performer and drew a lot less current than its bigger companion, the VN67AF....Power feed is the same as shown above for the BAX-1, except a RF Choke in the pre-amp is not required.

Fig. 4-16

Active Antenna

An Active Antenna can be considered as a relatively short antenna with a pre-amplifier contained within the antenna assembly....They normally consist of a short whip antenna some 3 to 9 feet long and the pre-amplifier is contained within a weather-proof housing that supports the antenna....Power to the pre-amplifier is fed through the coaxial cable that also feeds the receiving system by means of isolation resistors or RF Chokes.

Being of small size and light in weight, the antenna can be easily moved around the average homestead to find the quietest location as to signal-noise-ratio (S/N/R)....The antenna can be easily clamped, bolted, etc. to darn near any type of support....Since we are dealing with the LF range, height is not important, BUT S/N/R IS !....It may take some time and patience and a few extra feet of coax cable to find the best position, but the effort will be worth it !....In some cases, movement in only some 10 feet one way or 'tother will make a big difference in noise reception.

I have tried many transistors in the pre-amplifier circuit, bi-polars, FET's and in my opinion, the VMOS's gave me the best noise figure. The VN67AF provided excellent performance but the current drain at only 10 volts was over 100 ma....I settled on the VN10KM and found equal performance with reasonable current drain....This is important if battery power is used.

The pre-amplifier housing does not have to be shielded but has to be huskey enough to support the whip antenna in high winds....I assemble my pre-amplifier on a piece of perf. board $1\frac{1}{4}$" x $1\frac{1}{2}$" in size....See Fig. 4-17.

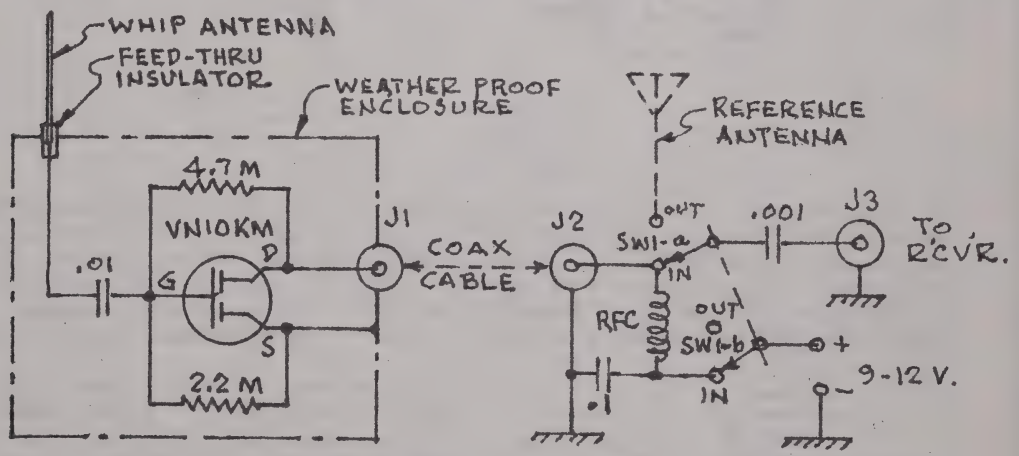


Fig. 4-17

The RFC should be effective at the lowest operating frequency.
SW1 is a DPDT switch to place active antenna in circuit or switch out same and put receiver on a reference antenna.
J1. J2 & J3 are coax connectors.

COILS & COIL WINDING

Even with the remarkable advances made in solid-state technology, there are very few radio and electronic circuits compatable with this scrapbook that does not require a wire wound coil, rf choke or transformer someplace or other in the circuit.

Regardless of the frequency or application requirement, a well wound coil will serve its purpose....Unfortunately, the proper coil to suit a desired circuit is not always available in your junk box or from the local radio part supply emporium....Therefor, it appears that learning how to "roll your own" is a valuably asset to the home constructor.

There is no mystery to coil winding once you understand the basic principles....A coil is nothing more than an inductance and the more turns used, the higher the inductance and in turn, the lower in frequency that it will be resonant at....In radio frequency circuits, coils are normally used with a capacitor across same to provide a resonant L/C circuit at the operational frequency.

In the medium to low frequency range coils are normally wound on a bobbin made of insulating material....These bobbins can be round, square or rectangular in shape and have a flange at each end to contain the windings....The core configuration of the bobbin is made to suit a powdered iron or ferrite core that can be inserted within the finished coil....The use of these cores greatly reduces the number of turns required on a coil to achieve the necessary inductance and reduces the dc resistance and offers an improved "Q"....Adjustment of the core penetration within the coil field can be used for tuning the coil to its desired inductance....Compared with a coil in "free space", by adjusting the penetration of cores within a coil field, frequency ratios of 10 to 1 up to 100 to 1 can be obtained.

The simplest ferrite core coil is the common slug-tuned type that I am sure most experimenters are familiar with....They consist of an insulated coil form with a slug that is mounted on a screw thread. By turning the screw, the slug can be adjusted within the coil field that provides a reasonable variation in the coils inductance.

At the other end of the scale, is the "pot core"....In this case, the coil bobbin, for all practical purposes is completely encapsulated within ferrite material....I intend in no way to discourage the use of pot cores, but the construction and availability of same , I find awkward to use for experimental endeavours.

There is however what I consider a very interesting in between called "E" cores....For some unknown reason I never see reference to the use of this configuration in the many construction articles contained in the various radio hobby oriented publications....If you can picture a square pot core configuration and slice away two opposing sides, you have the "E" core assembly....It is very similar to your common power supply and audio transformer except ferrite shaped "E's" are used instead of alloy laminations....These cores work with square shaped bobbins that is of no concern since a well wound coil dosn't care if it is wound on a round, square or rectangular bobbin.

Bobbins are available with plain flanges at each end or with "pin rail" terminals for PC board mounting.

I can offer these "E" cores with matching bobbins to interested experimenters, and a letter or post card will get you the info. The average "E" core has a permeability of 2000, however in certain sizes a 10,000 is available, but they are quite expensive and not necessary for normal applications.

The adjustment of the "E" cores within a coil field can produce a frequency excursion of some 70 to 1 that should provide an experimenter with quite a safety margin fooling with homemade coils, to obtain a desired inductance.

Since publishing the 3rd edition and Addendum of my scrapbook series, the manufacturer of the "Morris Coilwinder" went out of business....I tried to follow this up by seeing if the parts, tooling, dies, etc. were available, but got nowhere !

So, I decided to make my own coil winder....The most sophisticated machine tool I own is a drill press, so the project presented quite a challange to my ingenuity....However, I finally assembled a home-brew coilwinder that produces quite a professional looking coil and the details will follow in this chapter....If I can do it considering my limited machine shop facilities, I am sure anyone can duplicate the device.

My experiences has indicated that standard enameled copper wire used for inductances in tuned circuits for receivers, converters, VFO's and exciter stages of a transmitter is satisfactory, forget the use of same in small ferrite tuned inductances used for a tank and antenna coupling coil in a 160 to 190 kHz transmitter....Unless you want to build same wound on forms using #8 to #12 ga. copper wire of such a size that would hardly fit into a backyard storage shed, it is a "forget it".

So, we get to "Litz Wire".....Small compact coils using 1/2" diameter ferrite cores for tuning, have been used by successful LOWFERS for years, the basic problem is the availability of Litz wire....Not only the availability, but the price !....A friend of mine who is in the coil winding business recently told me that the price of #44 copper enameled wire just went up to about $50/lb OEM....Litz wire is made of many strands of fine enameled wire twisted and then normally wrapped with a nylon fabric overlay....In other words 63/44 Litz wire consists of 63 strands of #44 enameled wire....For any purchaser of available Litz wire, be sure that the enamel insulation on the wire strands are solderable....Stripping insulation from the fine strands of Litz wire can be a nightmare, though in many cases, GC Electronics STRIP-X will do an efficient job.

It is not too difficult to make your own Litz wire if you have some time and patience and a wind-free area to work with....Let us assume that you want to wind an antenna coupling coil on a form that will accept a 1/2" dia. ferrite rod....Since we are dealing with a multiple layer winding let us also assume that we will need 2-1/4" of wire in each average turn....If we want to wind 400 turns we will need a total length of wire that is 400 x 2.25" wich totals 75 ft. Find or arrange two structural supports that are separated by at least 75 feet and add a screw eye to each support....Since Litz

wire consists of multiple strands of fine wire, the idea is to string fine enameled wire back and forth between the eye hooks to make up the desired number of strands required....I would suggest that the use of wire finer than #40 not be used and the number of strands be not less than 20....A 1/4 lb. spool of #40 wire will have over 7000 ft. of wire.

The next step is to attach the spool wire end to one of the eye hooks and walk back and forth stringing the wire between hooks to get the desired number of strands....Dont use too much tension in this phase as you may break the wire....The next step is to start at one end and with your fingers, slide along the multiple strands to the other end to gather the strands to be reasonable taut....When satisfied that the wires are reasonably parallel to each other, solder all the strands at one end together....For the next step I suggest that you inlist the aid of a friend....Chuck the soldered end into a hand drill and pull the wires reasonably taut and start turning the hand drill....Have your friend walk along the length of twisting wires to help insure a distributed twisting effect (not bunched up at one end or the other).

When finished, wind the finished Litz wire up on a spool and you are now ready to wind an efficient coil.

Too conclude my subject of homebrew Litz wire, don't use wire with sophisticated coatings such as Formvar, etc...Be sure that the enamel is self-soldering or you will have a big problem.

To get back to coils for the basic frequency range of 10 to 500 kHz, I feel for the average LF buff that wishes to build a converter or possibly improve his existing set-up, consider the following choices for a coil arrangement that will efficiently tune through the desired frequency range.

1) As I mention in the Reception chapter, plug-in coils are probably the simplest answer particularly when a coil is used in a circuit that requires more than one connection to a coil (this considers the fact that in most circuits, one end of the coil is grounded).

2) For the converter that I describe in Fig. 4-2, I made up a set of six coils using "E" cores and matching bobbins....The main tuning capacitor is a double gang @ 365 pf each with the stators in parallel. This totals 730 pf and I also added a frequency extending capacitor switch with a 470 pf and a .001 mfd capacitor....Using a rotary type of switch for coil selection, I can tune from 500 to 5 kHz....The entire assembly is mounted on a perforated board measuring 2" x 3⅜". I mounted the rotary coil selecting switch and the frequency extending capacitor switch on an aluminum flanged plate mounted on the front end of the perforated board.

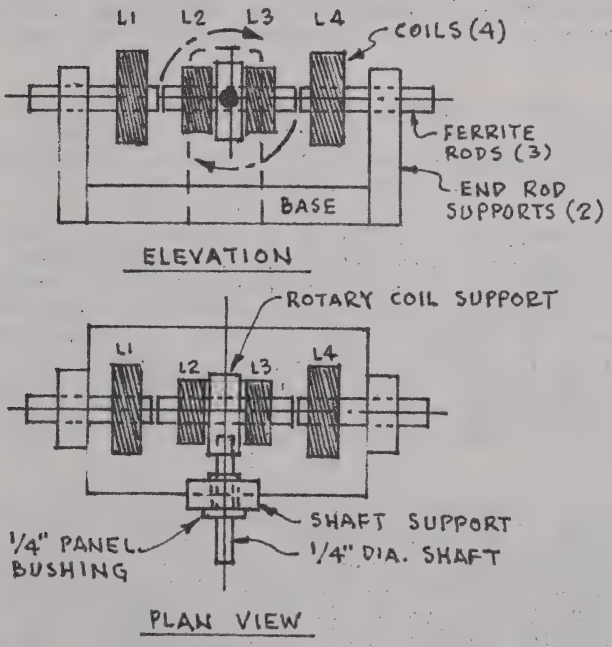
3) Is there another answer to plug-in or switchable coils for a converter that will provide this 500 kHz frequency excursion in the LF to VLF range ?....My experiments indicate that there is....The word Variometer might be foreign to the new breed of radio experimenters, but this could be the answer and in the early days of radio they did provide a multitude of required service....So let us consider an updated Variometer for "front-end" service in a converter.

A Variometer is a very interesting coil configuration and the use of same goes back to the early days of radio....The basic assembly normally consists of two coils mounted on the same axis with one fixed and the other rotatable within the field of the fixed coil....The windings on both coils are wound in the same direction and they are connected in series....The point is, that when the coils are used with the windings in the same "clock-wise" direction, maximum inductance is obtained and in this case, the windings "aid"....If the rotatable coil is turned 180 degrees, the windings now "buck" and minimum inductance is obtained....Why not use this arrangement using ferrite cores ?

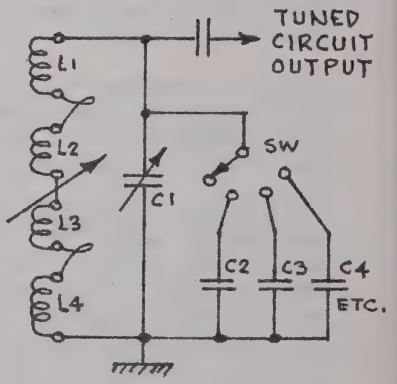
I had a supply of 5/16" diameter ferrite rods that a friend supplied me with and while I did not know their permeability, a check with a few coils on my Boonton 160-A "Q" Meter indicated that they were above 1200 and ideal for the LF range....So I decided to make a ferrite core Variometer as an experiment and it was quite encouraging....Sometimes we forget the ideas that the early experimenters went thru in the '20s and using these ideas with modern materials, it is worth the effort.

I wrote an article on this assembly in my column that appeared in the Jan. '79 issue of the LOWDOWN, but unfortunately, I did not receive too much "fan mail" regarding same since at that time, the majority of the LWCA members were "dial twisters and appliance operators" and not accustomed to fooling with a soldering iron.

Regardless, this scrapbook is dedicated to the "soldering iron specialists" and I pass the info on for what it is worth....See Fig. 4-18.



Suggested Construction



Schemeatic

Fig. 4-18

See Text

The idea of course, is to wind a series of coils on the ferrite rods all wound in the same clockwise direction....The end coils L1 & L4 are stationary....Coils L2 & L3 are arranged with means for proper support to be able to rotate 180 degrees within the centerline axis of the rods supporting coils L1 & L4....Minimal gap between the rods will provide best performance....A flexible wire connection between coils L1 & L2 and L3 & L4 is necessary to provide for the 180 degree rotation of coils L2 & L3.

For my first attempt, I used 100 turns for L1 & L4 and 50 turns for L2 & L3....Using a combination of 365pf/730pf for the tuning capacitor I was able to tune some 850 to 130 kHz....By increasing the number of wire turns by 10% and using additional capacity, as required, I zeroed in on the 500 to 10 kHz range....L/C circuits used in the LF range like a high "C" to "L" ratio, so don't be afraid to add more capacity across your coil to extend its tuning range....They can be switched out when not required.

For breaking small diameter ferrite rods to obtain a desired size use a file and make a "nick" in one side and then snap the rod at the "nick", just like breaking a glass rod or tubing....The broken ends can then be ground smooth by wiping on emery cloth.

I can assure any experimentally inclined radio buff that they can have a lot of fun fooling with this device.

***

While Fig. 4-19 illustrates the more popular types, some of the horzontal core bobbins are available with a center flange....Core hole sizes range from less than 1/8" up to 3/4" square....There are also many types that are available with flat solder lugs in lieu of the PC Board type terminal pins....It is impossible in this type of text to list the hundreds of bobbins available with square, rectangular and round cores....If you have a particular application, send me a SASE with required details and I will do my best to suggest the most applicable bobbin.

While square, the bobbins are easy to wind and since the "E" cores slide into the bobbins, the core penetration can be adjusted to zero in on the required inductance....To obtain maximum inductance, the winding should fill up the coil winding window as much as possible. The window is the space between the bobbin core and the flange periphery....This will depend on the number of turns and wire gauge used, but not really too important....I normally settle for #32 wire and use small bobbins for the MF to LF range and larger bobbins for the LF to VLF range.

Most of the PC Bobbins have a terminal pin spacing that will fit the IC spacing perfboards (Radio Shack Nos. 276-1394, 1395 & 1396). Also they will probably contain more terminal pins than required for the circuits I describe and the unused terminals can be ignored or they can be removed....Care should be used in removing terminals....Hold the pin rails length-wise and use long nose pliers....Grip the pin at its base and give a twist....Never hold the bobbin across the pin rails as you may snap the rail connection to the bobbin body.

The following offers "target figures" for wire turns on "E" Core Bobbins that I used for my converter and preamplifier, Figs. 4-2 & 4-3.

Frequency Range kHz	Total No. Turns	Source Tap Fig. 4-3
500 - 250	60	20
260 - 90	120	40
100 - 50	200	60
55 - 25	300	90
30 - 13	500	150
15 - 6	700	200

The above figures are based on a core permeability of 2000, but manufacturing tolerances can vary by +/- 25%....Again, depending on the permeability of the core material, a Pot Core would require less turns and a slug tuned assembly would require more turns....Further on in this Chapter I will go into a simple explanation of just what permeability is all about regarding coil inductance.

So let us consider that the next problem is to actually wind a set of coils that will tune the 500 to 10 kHz range....For the moment, let us forget the means we use to wind the coils....This can be done by hand winding or the use of other mechanical means that will be considered later in this text.

The basic requirement is to wind a set of coils that will provide the proper inductance in each coil, used with its associated tuning capacitors, to provide an un-interupted series of coils to cover the required tuning range....Since you can't wind a coil and look at it and say that this coil has "X" inductance and should tune "Y" to "Z" frequency, we need external devices that are simple to use that will tell us exactly what the tuning range of a coil with its associated capacitors really is.

In my mind, the simplest method is to construct a simple test oscillator circuit and use same with your coils to obtain the proper frequency coverage with each coil....The output of the test oscillator can be fed into a frequency counter or you must realize that any oscillator will put out harmonics of its fundamental frequency by multiples of x2, x3, x4, x5, etc....The fundamental frequency and its 2nd harmonic, or any other harmonics can be picked up on a receiver by loosly coupling the test oscillators output to a receivers antenna input.....The difference in frequency between each harmonic will be the coils fundamental frequency....The scheme I use requires a source tap on all coils, similar as required for my regenerative pre-amp, and my test oscillator is a Hartley configuration....See Fig. 4-20. While a source tap is not required on a coil used in my converter circuit Fig. 4-2, the minimal effort to provide same for use in my test oscillator was well worth the minor inconvenience.

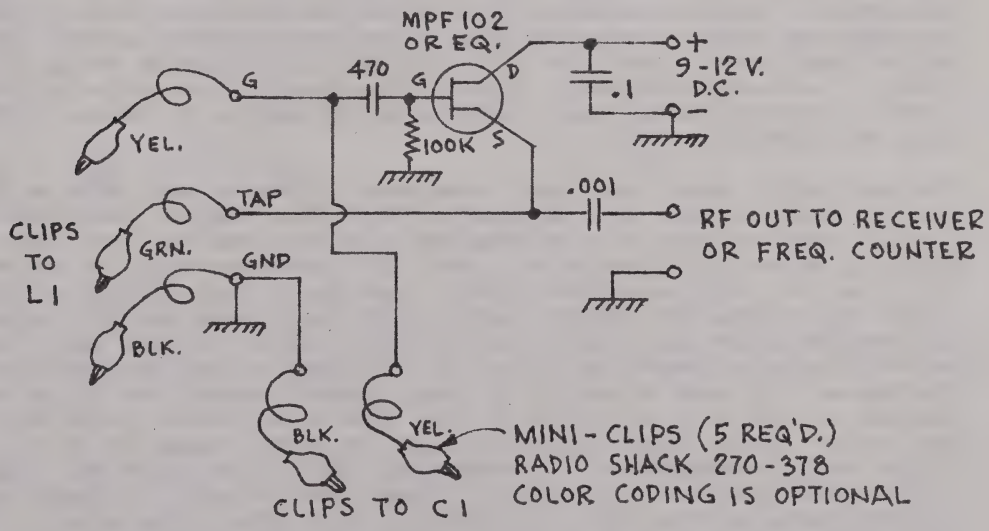


Fig. 4-20

Test Oscillator

Assuming that your converter or preamplifier is operational, any new wound coil can be placed in same and checked for frequency coverage....A signal generator will be most helpful for calibrating the tuning range of the coil, but in many cases, a signal generator will not tune below 75 to 50 kHz....In this case, for the lower end of the spectrum, you will have to rely on known operational stations as well as the ambient noise level and you should notice a decided "peak" in the noise level as you approach coil resonance....If you don't observe this, I would suspect a malfunction in the converter or preamplifier circuitry, or possibly in the coil itself, such as shorted turns or poor solder connections, etc.

So, to get to the "nitty grit", let us assume that you have finished a converter or preamplifier....I suggest that you consider a tuning range of 5 to 500 kHz....All the coils don't have to be wound at the same time, but while you are in the mood, why not get the mission accomplished ?

I suggest that you start with the higher frequency coils, starting at 500 kHz, since there are many Beacons in the 500 to 250 kHz range and following my "guide lines", it will not take you too long to get the feel of "turns to capacity ratio" for necessary frequency coverage.

This is the main reason I prefer the ferrite "E" Core assembly since they can provide the easiest means of obtaining a desired inductance. Using my "E" Core coils, working with a two section 365 pf variable tuning capacitor with frequency extending capacitors, I only required 6 coils to cover some 5 to 500 kHz with a comfortable overlap.

In winding a coil using any type of ferrite core material, the permeability of the core material has to be considered as this is MOST important as to the number of wire turns required to achieve any required inductance (see page 63)....In winding my coils using "E" Cores, I normally add about 5% more wire turns, particularly on the lower frequency coils, than required as it easier to remove turns than add them.

For zeroing in on my required inductance, I use a very simple fixture that is nothing more than a plastic Mini-Vice (Radio Shack #64-1801). I might mention that this scheme can also be used for Pot Cores....I place my wound coil bobbin with the "E" Cores inserted in the vice and clamp to full penetration and I use short mini-alligator clip ended wires into the operational circuit and check the frequency of the resonant circuit....Chances are that it is too high and I then have a choice of removing turns, or withdrawing the penetration of the Cores....I keep a supply of small rubber bands, cut up in small pieces, chunks of small plastic foam pieces and scrap paper and I can insert these scrap pieces between the outer faces of the "E" Cores and by varying the "E" Core gap, it will not take too long to achieve the desired inductance....Never use too much pressure on the ferrite cores as the are very brittle, like fine porcelain....I then apply epoxy cement between the ferrite core and the bobbin core. Never use the common household types of plastic cement as they have a horrible shrinkage rate upon drying and can ruin your inductance.

To take a breath for the moment in this coil winding chapter, I have reviewed the problems of wide range inductances required to tune the 500 to 10 kHz range by the use of plug-in or switchable coils, as well as a wide range tuning inductor called the variometer.

For the experimenter, it would not be fair, to not mention several other schemes that are worth experimental effort:-

1) I call it the "PUSH ROD TUNER"....In this case I wind a series of coils on bobbins that are cemented together or on a relatively long insulated tube or sleeve....The inside diameter of the tube or bobbins will provide a slide fit for a long ferrite rod....My most successful tuner uses a 1/2" dia. ferrite rod x 7½" long and I cemented six bobbins together with winding turns of #32 en. wire, starting with the following progression of turns on each bobbin from the ground end:- 90, 150, 225, 300, 350 & 400....Taps are provided between each coil and they can be connected to a single pole, 6 position switch....This arrangement using my standard tuning capacitor set-up, and by sliding the ferrite rod within the coil assembly, I can tune from about 490 to 8 kHz.....See Fig. 4-21

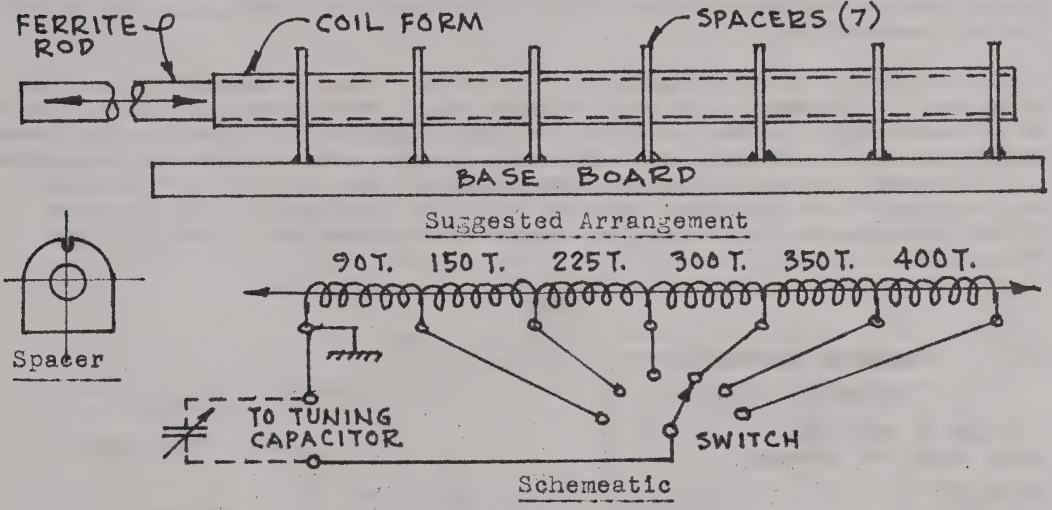


Fig. 4-21

For those who wish to make their own coil winding tube, I suggest that you first take your ferrite rod and wipe same thoroughly with a fine emery paper or cloth and then spray same with a "silicon spray". Then wrap the entire length of the rod with wax paper for a few turns and secure the ends only, with scotch tape.

The next step is wrap the core with a heavy bond paper....Cut the paper so that when the wrap is made, the ends of the original wax paper wrap is exposed....After every few turns, coat the paper with coil dope....Make sufficient wraps to provide a thickness of about 1/16"....Secure the paper end wrap with a strip of scotch tape and apply several coats of coil dope allowing each coat to dry before applying the next.

While not absolutely necessary, I suggest that spacers shaped as shown in Fig. 4-21 be cut out of stiff cardboard and be slipped on the tube....7 spacers will be required and should be equally spaced to suit the length of the ferrite rod....The flat bottoms should all be aligned and when spacers are in position, set the assembly on a flat surface and apply cement to the spacers....Later on, when the coils are wound, the spacers can be used to cement the finished coil assembly on a base board....When winding the coils, do not use too much tension on the wire or you will have difficulty in removing the ferrite rod....The final step, is to remove the rod and wax paper wrap.

It must be remembered that the closer the spacing between the coil winding diameter and the outside diameter of the ferrite rod is, the better inductance tuning range will be accomplished....In other words, don't expect good results if you plan to use a 1/2" dia. rod inside a 1" dia. coil.

2) The other scheme is to use "E" cores with matching bobbins....In this case, by using mechanical means to smoothly adjust the penetration of the cores within the coil bobbin, an extremely wide inductance range can be achieved in the frequency range of 100/1....5 to 500 kHz is not impossible.

I have tried several methods to accomplish this arrangement and the simplest is to mount the coil bobbin and core assembly at the center of a baseboard....Then mount a vertical bracket centered on the baseboard and coil assembly at each end....Holes are drilled through the end brackets on the extended centerline of the coil....A threaded rod engaged to a threaded bushing that is cemented to the ferrite cores are used to position the cores within the coil field....See Fig. 4-22

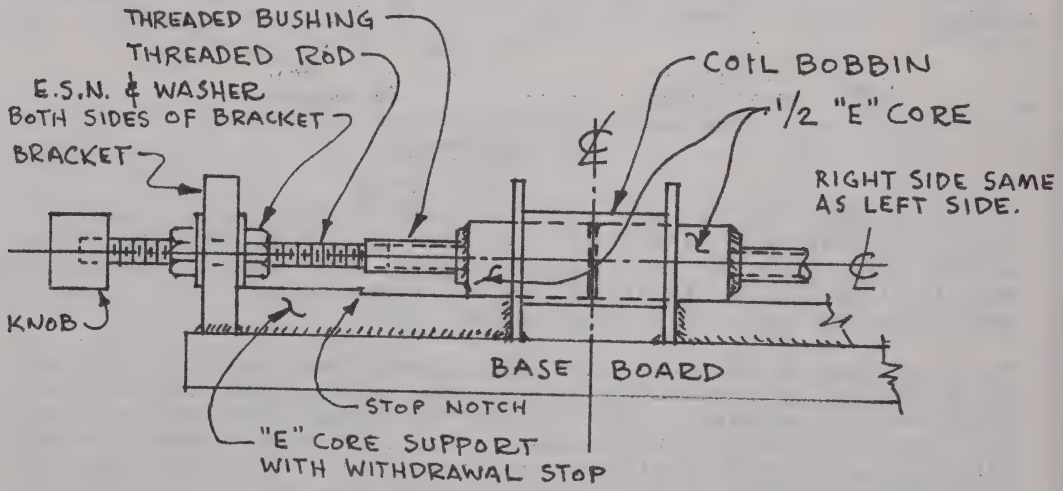


Fig. 4-22

Another arrangement can be used for Fig. 4-22 tho not quite as sophisticated, is to use push rods instead of the threaded feed. In this case, I suggest that 1/4" dia. brass or aluminum shafting be substituted for the threaded rods....In this case, standard 1/4" panel bushings can be installed in the end brackets....Careful alignment of the rods that have to be cemented to the "E" cores has to be made and I suggest that the coil bobbin, and all necessary parts of the assembly be made and with the cores in full penetration position, the rods can then be pushed in and cement contact to the cores be made.

I might note at this point, that while I have never experimented with using ferrite cup cores with this tuning arrangement, I see no reason why it would not work.

The basic idea in using the wide range "E" core coils just described, is that when the cores are in withdrawal position, the coil has minimum inductance....With full penetration, the coil has maximum inductance....The normal proceedure, tuning from the highest frequency into the lower frequency range is to start with both cores withdrawn. Start feeding one "E" core into the coil field and the tuning range will go lower in frequency....When the one half has reached maximum penetration, start feeding the second half into the coil....This will require two operations....After some experience, the two halves can be positioned using both hands to peak up a desired signal with the tuning capacitor at a compatable setting....The tuning capacitor is always used for peaking up the signal (fine tune), as the position of the "E" cores is only used to get the "target range".

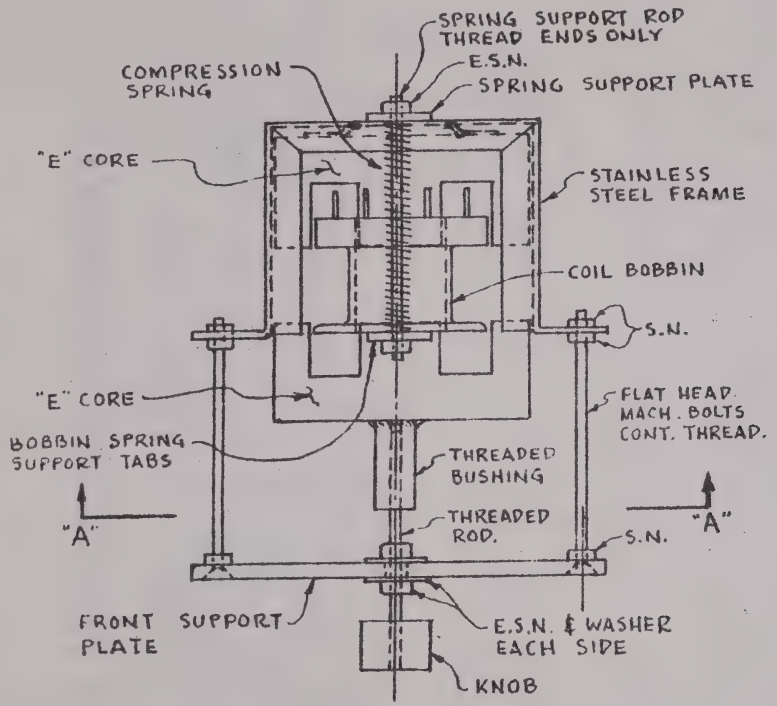
I decided to fool around with an arrangement that would provide a full withdrawal to full penetration of "E" cores within a bobbin using only one fairly precise positioning control.

In this case, the cores and bobbin have to be contained in a frame that will allow the proper adjustment in length for the cores from minimum to maximum penetration within the coil....Stainless steel frames are available for containment of standard core and bobbin sizes....Fig. 4-23 is the method I used to accomplish the problem.

Except for the frame, cores and bobbin, I purchased all necessary parts from the local hardware store....The secret is in the use of springs to always want to push the bobbin away from the rear "E" core that is cemented into the frame and this requires spring support tabs that have to be cemented to the front bobbin flange and a matching plate that has to be attached to the rear of the frame....Two rods with threaded ends have to be made to support the expansion springs. For medium to larger size "E" core assemblies, small diameter and long springs are available at a hardware store selling SELECT-A-SPRING. For smaller assemblies, I have used the spring out of the common ball point pen and available at any stationery store (or defunct pens).

Fig. 4-23 is for guidance purposes only, but it works....The notation E.S.N. is for an elastic stop nut (or equal) and S.N. for a std. nut.

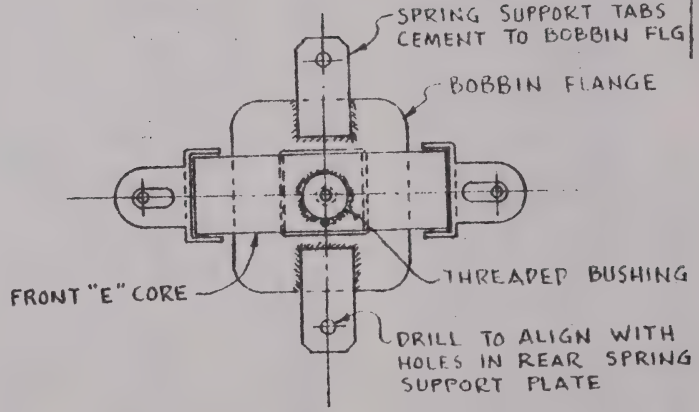
This arrangement drawing is offered for guidance purposes only...The spacing and lengths of the various components will have to be adjusted to suit the bobbin, "E" core and frame assembly size used....Have fun !



ASSEMBLY

WIDE RANGE TUNING INDUCTOR

SHOWN IN MINIMUM INDUCTANCE POSITION


SPRING SUPPORT TABS CEMENT TO BOBBIN FLG
BOBBIN FLANGE
THREADED BUSHING
FRONT "E" CORE
DRILL TO ALIGN WITH HOLES IN REAR SPRING SUPPORT PLATE

SECT. "A-A"

FIG. 4-23

NOT TO SCALE

Machine Winding

Coils used in the low to very low frequency range require quite a few turns of wire....In most applications, multiple layer solenoid windings are acceptable to achieve the desired inductance....If you have patience, a good coil with hundreds of turns can be made using simple hand winding....However, a simple assembly can be fabricated that can make coil winding a pleasure instead of a task.

There are two important features required in a simple coil winder:-

1) A means of turning the bobbin in a steady and well supported manner with a simple hand crank....A threaded shaft is suggested to secure the coil bobbin using washers and nuts both sides.

2) The bulk wire spool should be supported in such a manner that will permit the wire feed to the turning bobbin be located within its coil winding length....Normally, your right hand will turn the crank and the wire feed to the bobbin will be guided with the fingers on your left hand.

Fig. 4-24 is an arrangement suggestion that is simple to build and well worth the effort....Physical dimensions should be adjusted to suit your maximum size coil lengths and diameters that you may wish to wind.

For the coil bobbin support rod, I use a std. 1/4 NC 20 threaded rod. This will accept coil bobbins with a minimum core diameter of 1/4". For bobbins with a larger core diameter, washers of suitable size have to be used and the bobbin centered on the rod using nuts to clamp same in proper position.

For smaller coil bobbins, I do not use the 1/4 - 20 threaded rod and fashioned a simple bobbin support using a 1/4" dia. bushing about 1/2" long....The hole inside the bushing will accept a 6-32 RH machine screw and it should be at least 1-1/2" long....The 6-32 screw is contained within the bushing with a hex. nut....The round head should be filed around the edges to make same conform to the 1/4" bushing. This small bobbin holder can now be inserted and secured in the shaft coupling connected to the hand crank....The small bobbin can now be centered on the 6-32 screw and secured with a nut.

The bulk wire supply spool support is a simple gimmick....Two vertical posts are attached to each side of the baseboard to support a dowel that will hold the spool....While notches can be cut into the top of the supports to contain the dowel, some means must be used to prevent the spool support dowel from horizontal movement....I personally prefer to insert metal pins at the top of the supports and drill matching holes in the wire spool support dowel.

Counting turns is strictly a memory process, keep a note pad handy for turns made in case of an interruption, also a piece of stick tape to secure the windings made....For sophistication, many means of the addition of a turns counter can be contemplated.

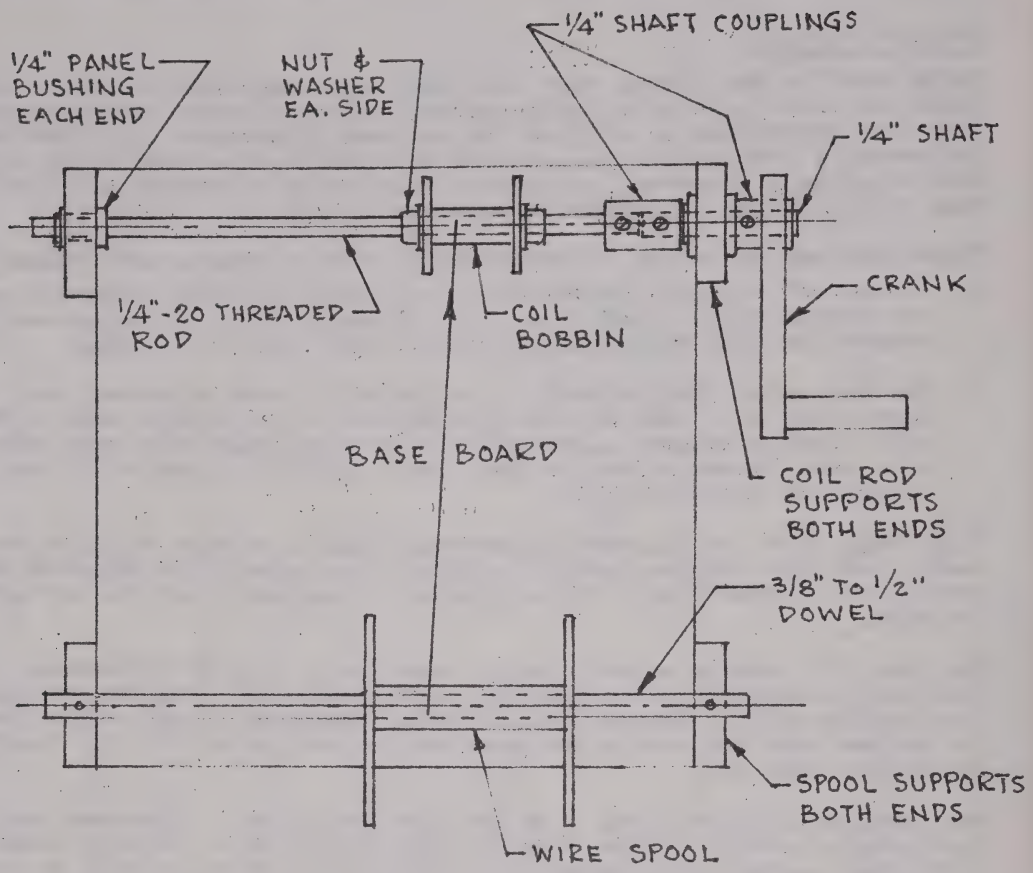


Fig. 4-24
Not to Scale

The baseboard should be huskey and I suggest a 12" wide x 1" thick piece of pine shelving about 12" long.

For the coil winding shaft supports, I suggest 1/4" to 3/8" thick plywood to accept the 1/4" panel bushings....For the wire spool supports, firring strips (1" x 2") can be used....I used small nails with the heads cut off for the dowel securing pins.

The centerline height of the coil support threaded rod should be of sufficient height to provide proper clearance for the crank over the base line....The wire support dowel can be located at the same height.

The 1/4" threaded rod is a hardware store item and the 1/4" panel bushings and shaft couplings should be available at any good radio part supply store....For the hand crank, see my details on the "Universal Coil Winder" described next.

A Home-Brew Universal Coil Winder

Upon learning that the Coilmaster Coil Winder was no longer available, and while mine was still going strong, due to the space I devote to coil winding in my scrapbook series, I decided to design and build my own machine using only simple hand tools and nothing more sophisticated than a drill press and easily available parts for its construction.

A coil winding machine capable of winding duo-lateral (honeycomb) type of windings, also known as self supporting types, require four basic design considerations:-

1) A means of rotating the coil form and supporting same in a stable and steady manner.

2) A cam driven wire feed assembly that will feed the wire to the coil form as it rotates back and forth making a good wire lay.

3) A simple gear-train that will provide a slight difference in the clockwise rotation per turn for the hand crank driven coil form and the wire feed assembly.

4) A steady support for the bulk wire spool.

The simplest means of driving the cam and its shaft assembly that actuates the wire feed as the coil turns, is with a pair of coupled gears mounted on the coil turning shaft and the cam shaft.

Another shaft is arranged to ride on the periphery of the cam and it supports the wire feed nozzle assembly that lays the wire on the rotating coil form....This shaft is spring loaded to insure that the shaft will always maintain proper contact with the rotating cam as it turns....The pitch of the cam will determine the width of the wire lay on the coil form....In other words, as the coil form turns, the wire feed nozzle that is actuated by the cam, will move back and forth as it feeds wire to the rotating coil form.

The ratio of teeth number in each gear is important as this will determine the spacing between each wire in each layer....If the same number of teeth was used in both gears, the wire in each lay would fall upon itself and a scrambled finished winding would result. Within reason, the larger the gear ratio, the wider space between each wire in the layer will result.

My coil winder grew like "Topsy" and after correcting a few "boo-boos", I ended up with a winder that produces a very professional looking coils....I am sure that any experimenter following my basic design and lay-out will be pleased with the results of their labor.

Fig. 4-25 shows the arrangement of the various assemblies and can be used for guidance purposes.

Universal Coil Winder, cont'd.

The gears may be the most difficult part to find....I called quite a few places listed as "power transmission co's." in the yellow pages and found one that had a reasonable supply of small gears....When I small, I don't suggest using gears of much under 2" diameter....I obtained two matching gears, one with 77 teeth and the other with 83 teeth....They were brass and supplied with hubs, but not tapped for set screws....I had to drill the hubs and tap 6-32 for set screws.

The Cam (#12) is a very important part of the machine and probably the most difficult part of the machine to fabricate....I checked my junk box and found some huskey bakelite tuning knobs...They had standard finger flutes around the sides that had to be removed and would give me a cam diameter of 1-1/2" diameter....The knobs had a metal insert with a set screw to take a 1/4" shaft....I had to drill through the knob with a 1/4" drill to take the cam shaft....I then drilled 5/16" from the front of the knob to the metal insert....The 5/16" dia. will provide clearance for the cam shaft.

To remove the finger flutes from the knob, I clamped a cutting bit from an old circle cutter to the side of my drill press bed....I chucked the knob with a short length of 1/4" rod into the drill press chuck and adjusted the bed and feed to machine off the flutes....The details for forming the cam will be described later....For those who may wish, you might check with a few local machine shops and get a price for machining the required cams.

The structural parts for assemblies (A) & (B) were cut from 3/8" plywood with 3/4" x 1" blocks to provide additional support....The baseboard is 3/4" plywood.

The arrangement is shown in Fig. 4-25 and can be used for guidance purposes, however dimensional changes can be made to suit the desire of the constructor....The following is detailed construction advice:-

Assembly (A)- Hand Crank Coil Turning Assembly

Elevation "A-A" should be self-explanitory....I cut the hand crank #1 from 3/8" plywood and used a 1-3/4" length of 1/2" dowel as the handle....I drilled the crank and cemented in a shaft coupling #3 with a 1-1/2" length of brass rod....The crank & rod is sandwiched through the front support and panel bushing #2 to another coupling #3....This coupling is used to connect the threaded coil support rod to the crank assembly....1/4" hex. nuts and washers are used to contain the coil form in proper position.

At the rear, I sandwiched a half coupling (std. coupling cut in half) #8 and gear #9 through the rear support and its panel bushing #2.

To assemble, I first cut all the wood pieces to proper size and then clamped the front and rear supports together and drilled the necessary holes for the panel bushings....I might mention at this point that the panel bushings I obtained were a little short to engage the nut through the 3/8" plywood and I had to drive the bushings into the plywood with a hammer a little bit to engage the nut.

Universal Coil Winder, cont'd.

I then assembled the parts in place with clamping and proper cement at all joints with the coil turning shaft assembly in place....It is important that proper alignment of the shaft is insured before the cement dries....After the cement dried, I added brads to the supports and blocking to provide additional security.

Assembly (B)- Cam Driven Wire Feed Assembly

This assembly provides for two mechanical functions....One is to rotate the cam #12 through the gear train #9 & #10 that in turn, actuates the second motion of providing a lineal movement for the wire feed nozzle #14 that lays the wire on the rotating coil form.

For proper function of the machine, the proper alignment of the shafts and their supports is most important for a friction free movement of the cam shaft and wire feed rod motions.

Cut all the wood structural supports to size....Clamp the rear and intermediate supports together and drill the hole for the cam shaft bushings....Then clamp the intermediate and front supports together and drill the holes for the wire feed shaft bushings....The centerline of this hole should be on the horizontal centerline of the cam and outboard on the cam's radius.

The rear and intermediate supports with the wood blocking are cemented in place and clamped to insure proper alignment and rotation of the cam shaft....After the cement has dried, the front support and blocking is cemented in place within reasonable alignment for the wire feed shaft....A fender washer is used to support the front end of the wire feed shaft in lieu of a bushing and is used to insure proper movement of the shaft....A "C" clamp is used to insure proper positioning of the washer and it is cemented in place....In positioning the wire feed shaft, the compression spring #16 is not used....After all cement has dried, brads are nailed into the supports and blocking for additional strength.

The wire feed nozzle assembly should be fabricated and all other parts assembled on the shaft to insure proper fit and alignment with the cam shaft assembly....The half coupling #8 should be adjusted so that the compression spring #16 will provide sufficient force that the rod #13 will firmly ride on the cam periphery as it rotates.

The wire feed nozzle, Assembly #14 that I detail, will speak for itself and here again should be used for guidance purposes....The nozzle accepts the wire from the bulk spool and guide the wire to the rotating coil form....This requires a friction free axial movement, yet it is most importatant that sidewise movement between the positioning half couplings and washers be held to a minimum if a good wire lay is to be obtained.

For the nozzle, I used a piece of small diameter copper tubing about 3-1/2" long....The bulk wire spool end should be reamed and flared slightly to provide a smooth entry for the wire and avoid scraping the insulation.

Universal Coil Winder, cont'd.

The coil feed end should provide a smooth close fit for the wire exit....I make a "hair pin" shaped loop of #18 bare copper wire for the wire lay guide....File the tube end to a bevel and remove any sharp edges, then solder the wire feed guide to the tube....I then use the shank of a twist drill that is slightly larger in diameter than the wire size used and insert the drill in the guide with a pitch that would simulate the actual wire feed to the bobbin....I then fill in the open portion of the guide with solder....See Assembly 14 for a suggested construction guide....For well wound coils, you should use a separate nozzle for each wire size.

ELEVATION "B1-B1" - CAM ASSEMBLY

The assembly as shown should be self explanitory...The cam shaft is supported by the panel bushings in the rear and intermediate supports. The cam gear #10 and the cam itself should sandwich the rear support bushing #2 with washers, yet not too tight.

As mentioned in the text, the cam is probably the most difficult item to fabricate, yet the scheme I used is not too complicated and it did work....If you wish to spend a few bucks, as I mentioned in the text, you can kick the cam idea around with a local machine shop....A word of warning however, don't fabricate the cam from soft aluminum as it will be too soft to properly actuate the cam rod #13....Brass is probably the best bet.

I explain how I made my cam forms in the preceding text, and after they have been turned down to the proper diameter (not less than 1½") I wrapped a strip of paper around the circumference of the form and made a pencil mark on the paper strip to indicate the total length around the periphery of the cam....I then cut a 1-1/4" wide strip of brass about 1/16" thick to the length indicated on the paper strip. The next step was to cut the cam configuration as indicated on my detail of the "Cam Rim Cutting Pattern"....After this surgery, the cam strip is flattened and all cut edges are smoothed off.

The next step is to mount the cam rim on the form....Using long nose pliers, I bent both ends of the brass strip to as close a radius of the cam form as possible....I then wrapped the metal strip around a smaller diameter form than the cam form and obtained a fairly respectable split ring....I then mounted the split ring on the form using a spiral feed type of hose clamp to check the mating ends....Possibly, you may have to adjust the final fit with a file....Remove the ring after you are assured of a good fit and apply cement to the periphery of the cam and reassemble using the hose clamp....If you end up with a slight gap between the cam rim endings, I suggest you fill in the gap with solder and then file to provide proper contour....The Cam Assembly #12, as detailed can now be followed for completing the finished product.

Of course, a different cam will be required for each pie width that you may wish to wind.

Universal Coil Winder, cont'd.

ASSEMBLY (C) - CLAMP BOARD

The detail I show in Elevation "C-C" is the scheme I used, though other means can be used with various clamping devices....The idea is that some means must be used to support the cam and wire feed assembly in proper position to suit the gear engagement and wire feed to the coil form....If gear ratios are changed, a simple adjustment in positioning the assembly will be required.

ASSEMBLY (D) - COIL WIPER BLADE & SUPPORT

This assembly was added to my machine after I had wound many good looking coils....It helps keep a little pressure on each wire lay as the coil form rotates and I feel it helps when winding wider type of coil pie's....If properly aligned, it acts like a finger laying with minimal pressure on top of the wire lay....To be honest, if care is used in winding your coils, it is really not necessary.

GENERAL COMMENTS

In operating the machine, the crank is turned clockwise and since one turn of the crank is one turn on the coil, I saw no reason to add a counter....I suggest that a piece of paper and pencil be kept handy to make a note of the turns number in case of an interruption. Also keep a piece of gummed tape handy to secure the winding.

To start a winding on the coil form, I cut a piece of scotch tape about 1-1/2 longer than the form circumference and width should be wider than the coil pie width....Gummed side down, I make about a 1/3rd wrap around the coil form and then fold it back on itself, gummed side up for a full wrap....This will give the first few layers of wire turns a sticky surface to help insure a good winding pattern.

Since we are not using fancy bearings, etc., a drop of oil should be placed on all shaft bushings, gear surfaces, compression spring and the cam rim to eliminate friction....Be sure that the coil form is well secured and all set screws are tight.

Enameled wire is difficult to use for this type of winding as it is slippery and the turn-around at the end of each winding will tend to slip....A nylon wrap such as found normally on litz wire is ideal. If you use enameled wire, I suggest that you stretch the desired length of wire required between two supports and the wire be given a coat of liquid rosin....Let the rosin dry and then wind up the wire on a spool....Clean the nozzle after use.

When the coil pie is finished, I suggest that the coil be given a coat of good coil dope like "Q MAX".

If questionable material is used for the coil form, I suggest that the form be dry and given several coats of coil dope.

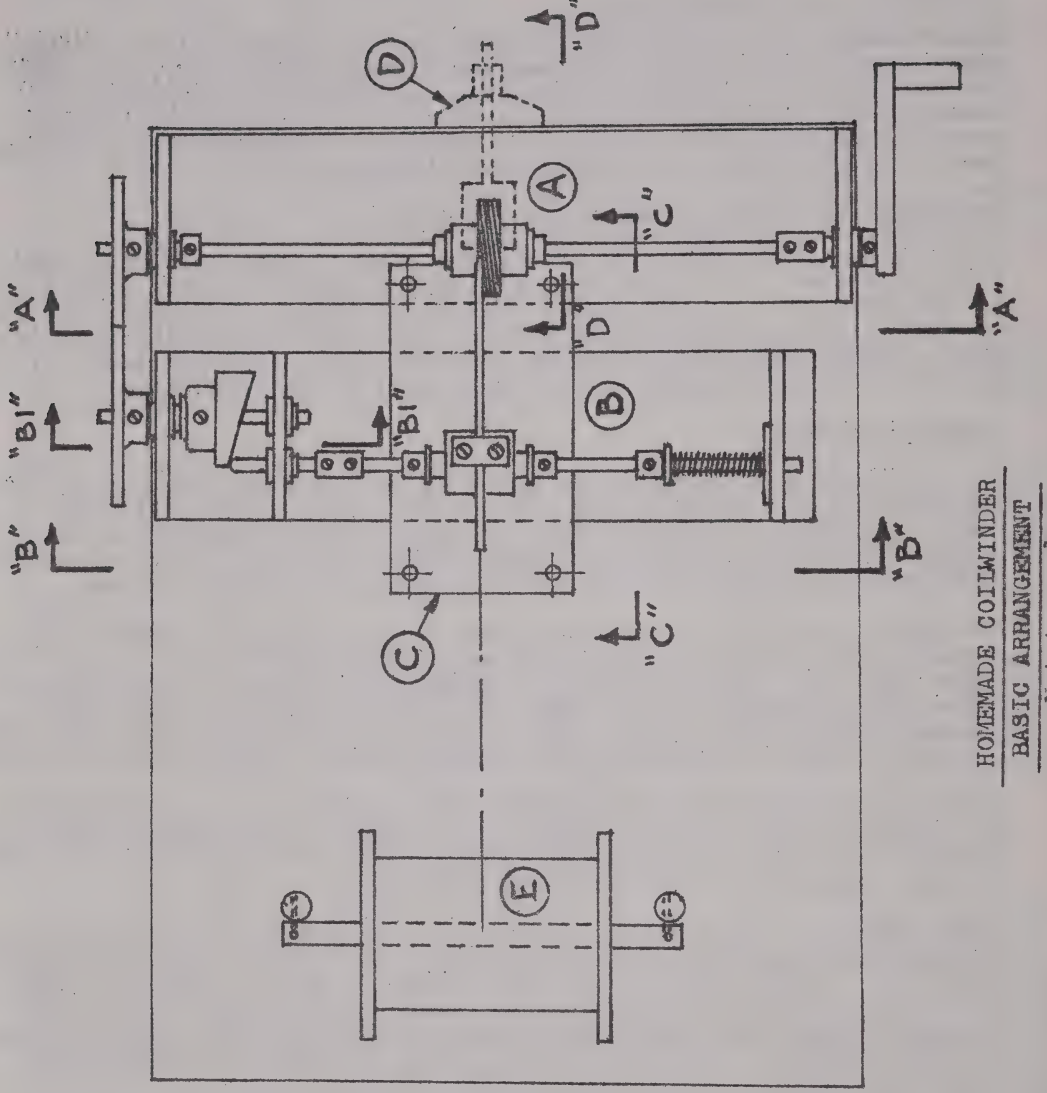
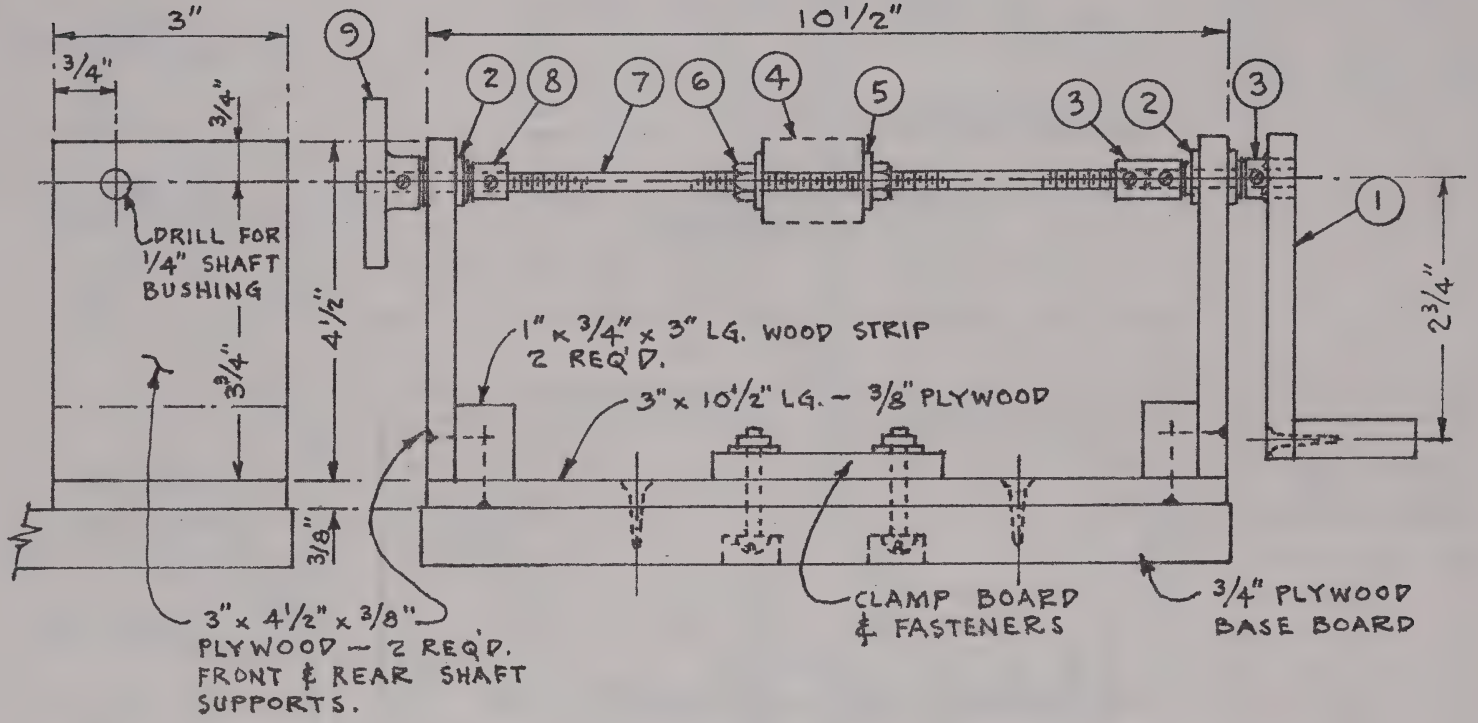

D
"D"
A
"C"
"A"
"A"
D
"B1"
"B1"
B
"B"
"B"
C
"C"
E
HOMEMADE COILWINDER
BASIC ARRANGEMENT
Not to scale

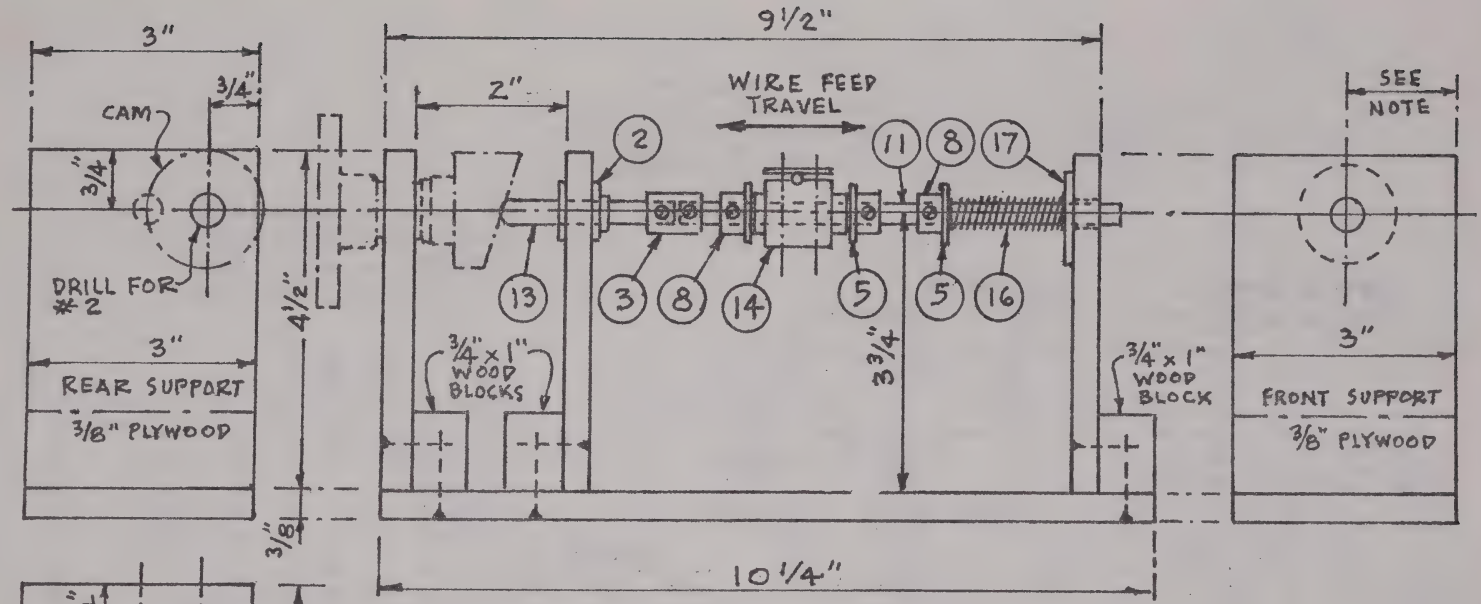
Fig. 4-25



ELEVATION "A-A"

COIL TURNING ASSEMBLY

Half Size

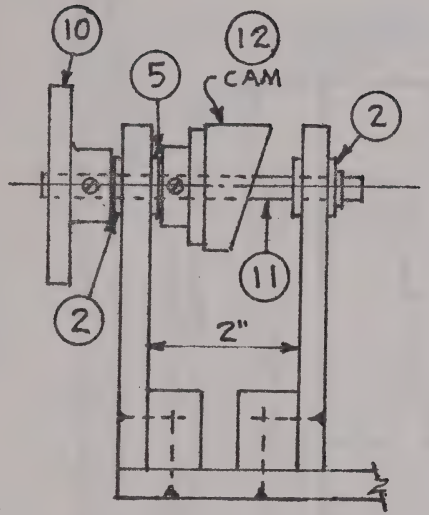


ELEVATION "B-B"

CAM DRIVEN WIRE FEED ASSEMBLY

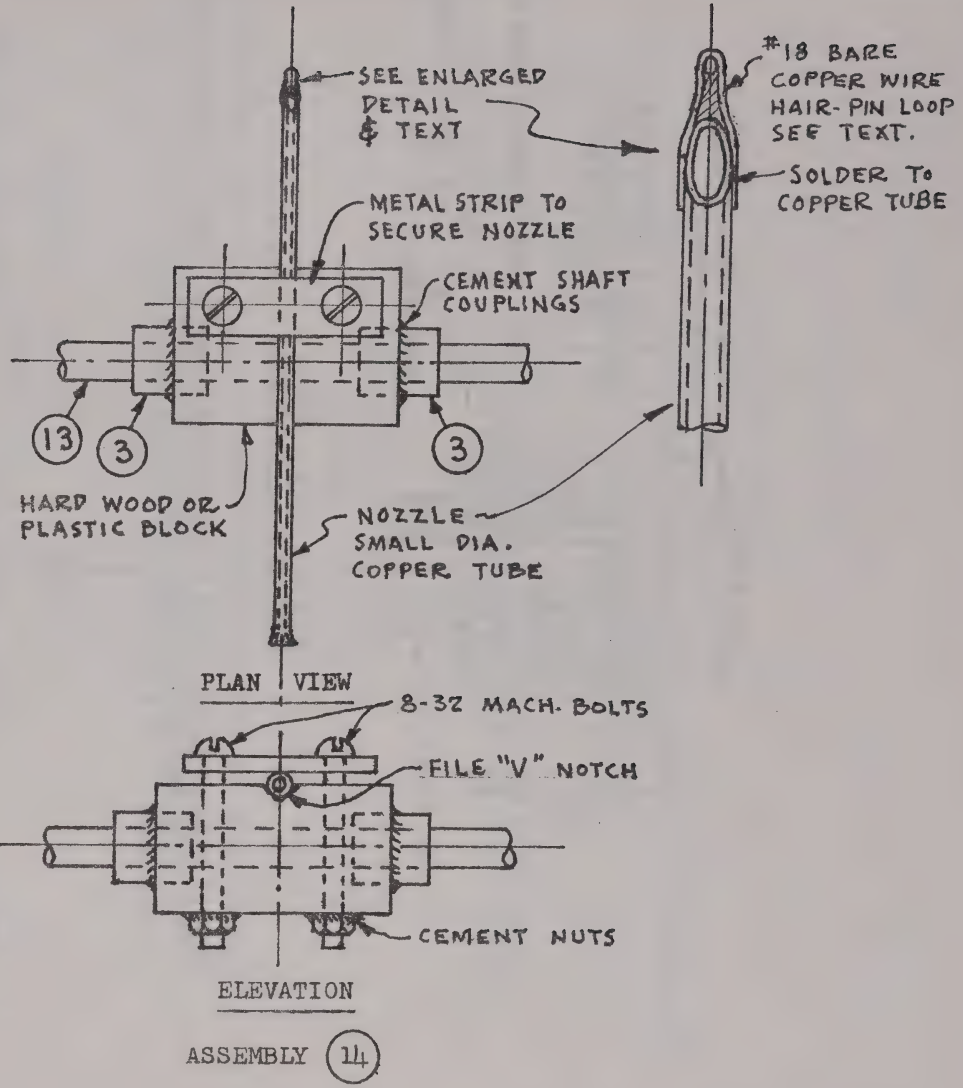
Note:- Dimension "Y" for the wire feed actuating rod panel bushing #2 should be centered on the radius of the cam.

Chuck the brass rod #13 in a drill press and with a file, round off the end that contacts the periphery of the cam.

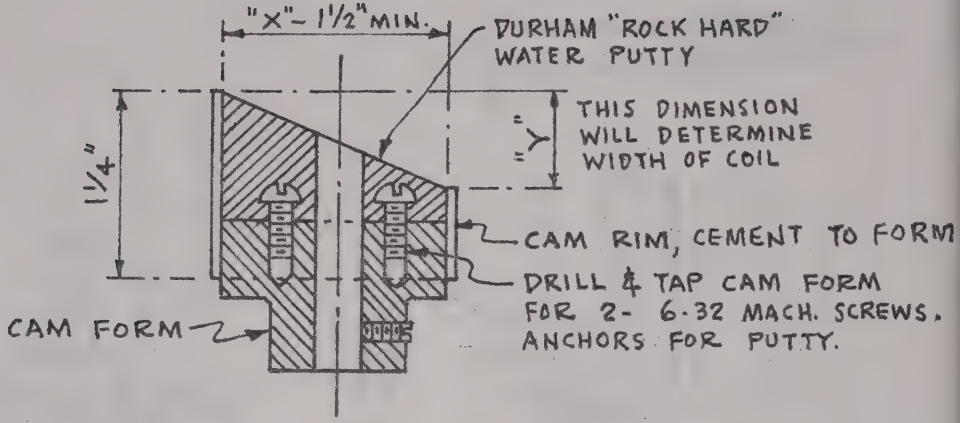


ELEVATION "B1-B1"

CAM, CAM GEAR & SHAFT SUPPORT

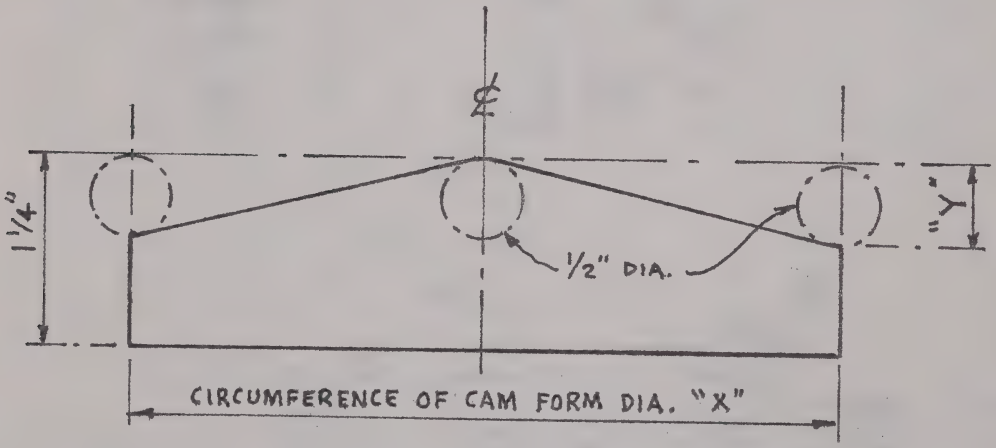


ASSEMBLY (14)


"X"- 1½" MIN.
DURHAM "ROCK HARD" WATER PUTTY
THIS DIMENSION WILL DETERMINE WIDTH OF COIL
Y
1¼"
CAM RIM, CEMENT TO FORM
DRILL & TAP CAM FORM FOR 2- 6-32 MACH. SCREWS. ANCHORS FOR PUTTY.
CAM FORM

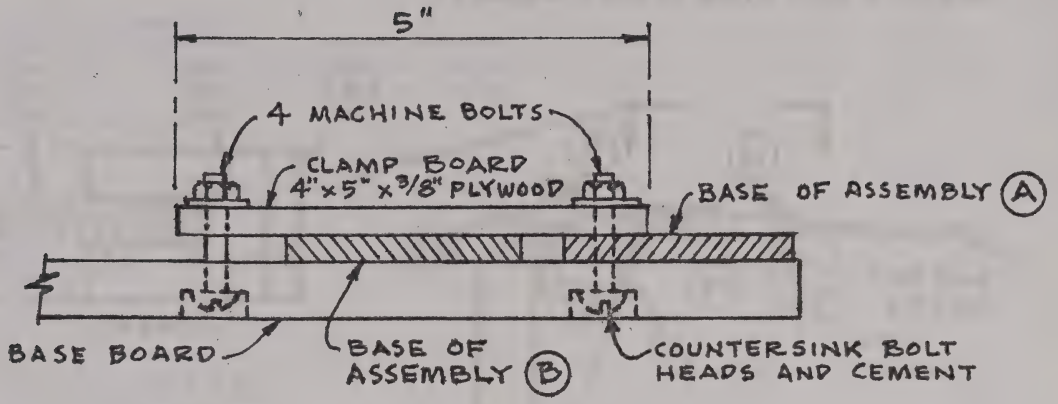
CAM ASSEMBLY (12)

Note:- A hose clamp can be used in lieu of cement to contain the Cam Rim to the Cam Form.



CAM RIM CUTTING PATTERN

Note:- I cut my cam rims from 1/16" thick aluminum strip, but I see no reason why brass or copper strips can not be used.

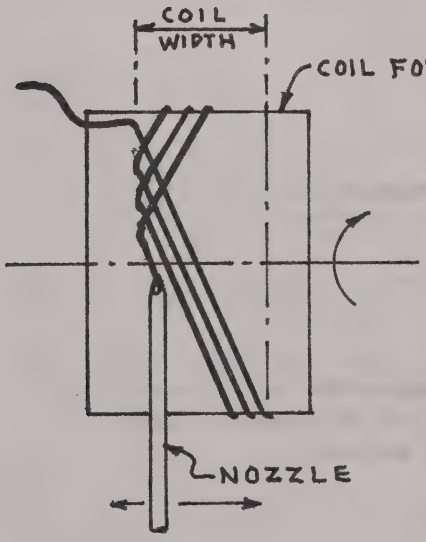


ELEVATION "C-C"

CLAMP BOARD

The clamp board is used to secure the cam drive wire feed assembly (B).

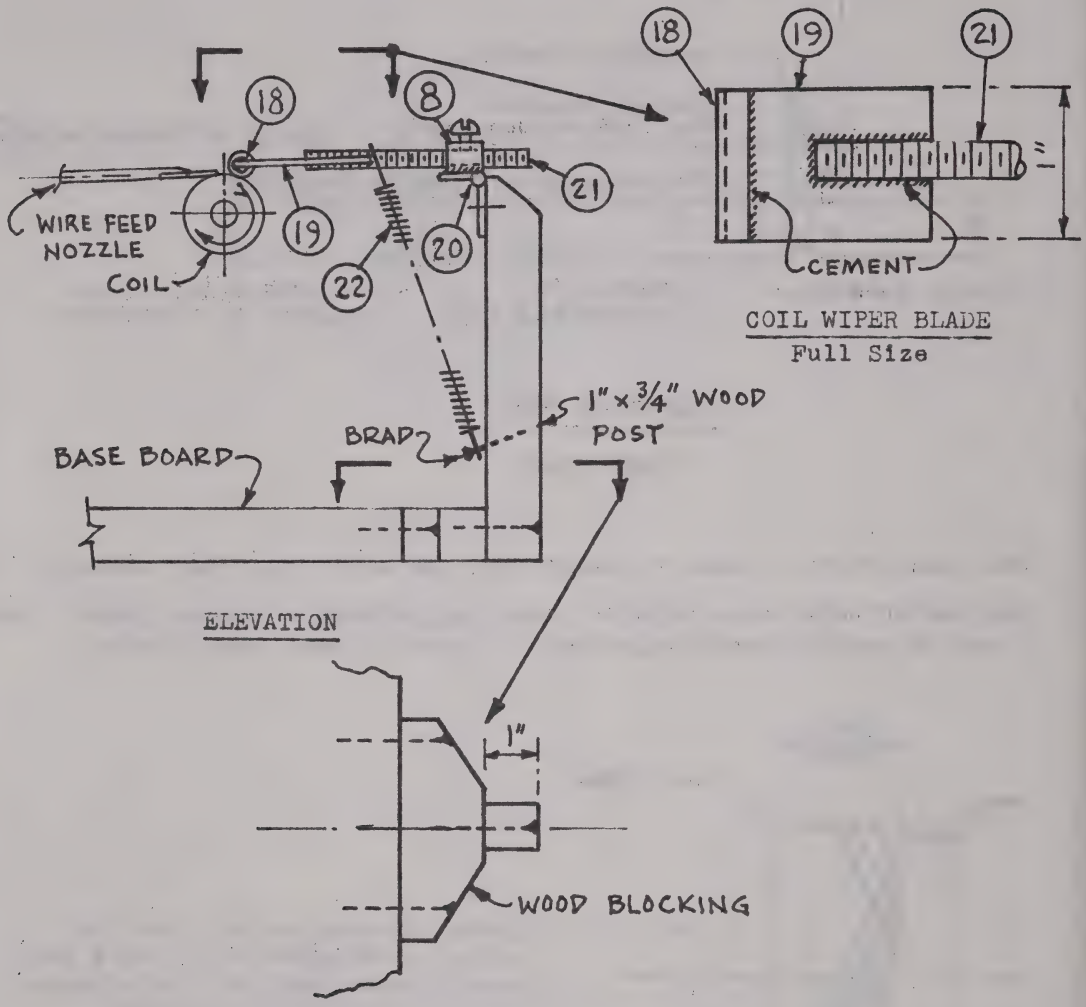
The use of this board permits proper adjustment to engage gears, Items 9 and 10 and to permit adjustment in case of gear ratio change.



(Sketch showing how the wire lay
(pattern developes as the wire feed
(nozzle moves back and forth across
(the coil form as it rotates.

ELEVATION "D-D"

Detail of coil wiper blade & support



COIL WIPER BLADE
Full Size

PART DESCRIPTION

(8) 1/4" half coupling....Solder to hinge #19
(18) 1" length of split jacket of RG-58 or 59 co-axial cable
(19) Wiper blade....Cut from wood paint stirrer
(20) Small brass hinge
(21) Short length of 1/4" threaded rod
(22) Select-A-Spring #84

HOME MADE COIL WINDER

BASIC ASSEMBLIES

(A) Hand Crank Coil Turning Assembly
(B) Cam Driven Wire Feed Assembly
(C) Clamp Board
(D) Coil Pressure Plate Assembly
(E) Wire Spool Support....I used wood dowels, however it should be fabricated to suit the type of wire spool used.

DESCRIPTION OF PARTS

(1) Hand Crank
(2) 1/4" Panel Bushing
(3) 1/4" Shaft Coupling
(4) Coil Form
(5) 1/4" Std. Washer
(6) 1/4" Hex. Nut
(7) 1/4" Threaded Rod
(8) One Half 1/4" Shaft Coupling (Cut from full coupling)
(9) Coil Shaft Gear....77 teeth) Suggested Ratio
(10) Cam Drive Gear.....83 teeth)
(11) 1/4" Cam Shaft Rod....Brass
(12) Cam
(13) 1/4" Brass Rod (Actuated by cam)
(14) Wire Feed And Nozzle Assembly
(15) 1/4" Brass Rod (to contain Item 14 and Spring Item 16)
(16) Compression Spring (SELECT-A-SPRING #85)
(17) 1/4" Fender Washer

SOURCE FOR PARTS

The Panel Bushings and Shaft Couplings should be available at any well stocked radio part supply store....I obtained mine from Modern Radio Labs, P.O. Box 1477, Garden Grove, CA 92642....They have quite a most interesting and nostalgic catalog listing parts I havn't seen since the early '30's....50¢ should get you a copy.

For the Gears, check the "Yellow Pages", Power Transmission Companies. This will be your biggest problem, at least it was mine !

The balance of items came from several well stocked junk boxes, the local hardware store and lumber yard.

44 and 88 mh Toroid Inductors

Most radio experimenters are familiar with these common and inexpensive toroids that are available on the surplus market and there have been many articles published on the use of same for various filter applications....The use of a good audio filter for weak signal LF reception should be encouraged and most experienced LOWFERS use them, as required.

It is not the intent of this text to dwelve into the designs of the many types of filter net-works that are described in any good radio handbook....There are many cases however, where the 44/11 mh and the 88/22 mh toroids may not be quite the proper inductance value for a required design....By using the toroids in series and parallel and by removing turns, a wide excursion in inductance values can be achieved...There was an excellent article on this by E.E. Whetherhold (W3NQN) that appeared in the Sept. '68 issue of QST Magazine....See Figs. 4-26 and 4-27 for graphs indicating turns removed/inductance.

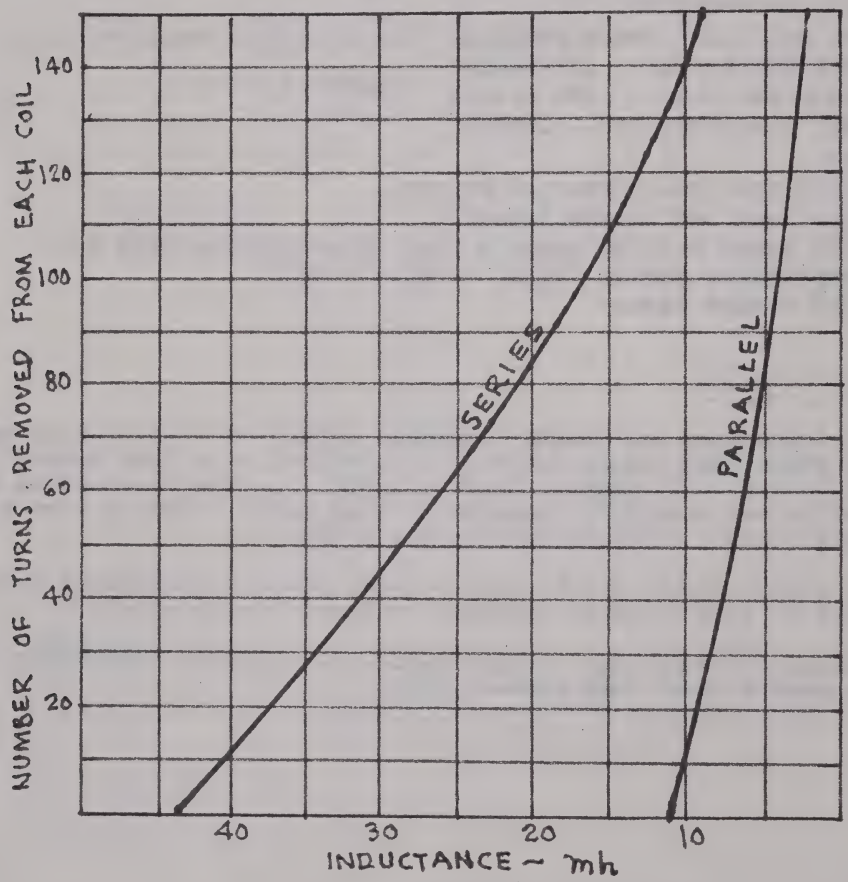


Fig. 4-26, 44/11 mh Toroids

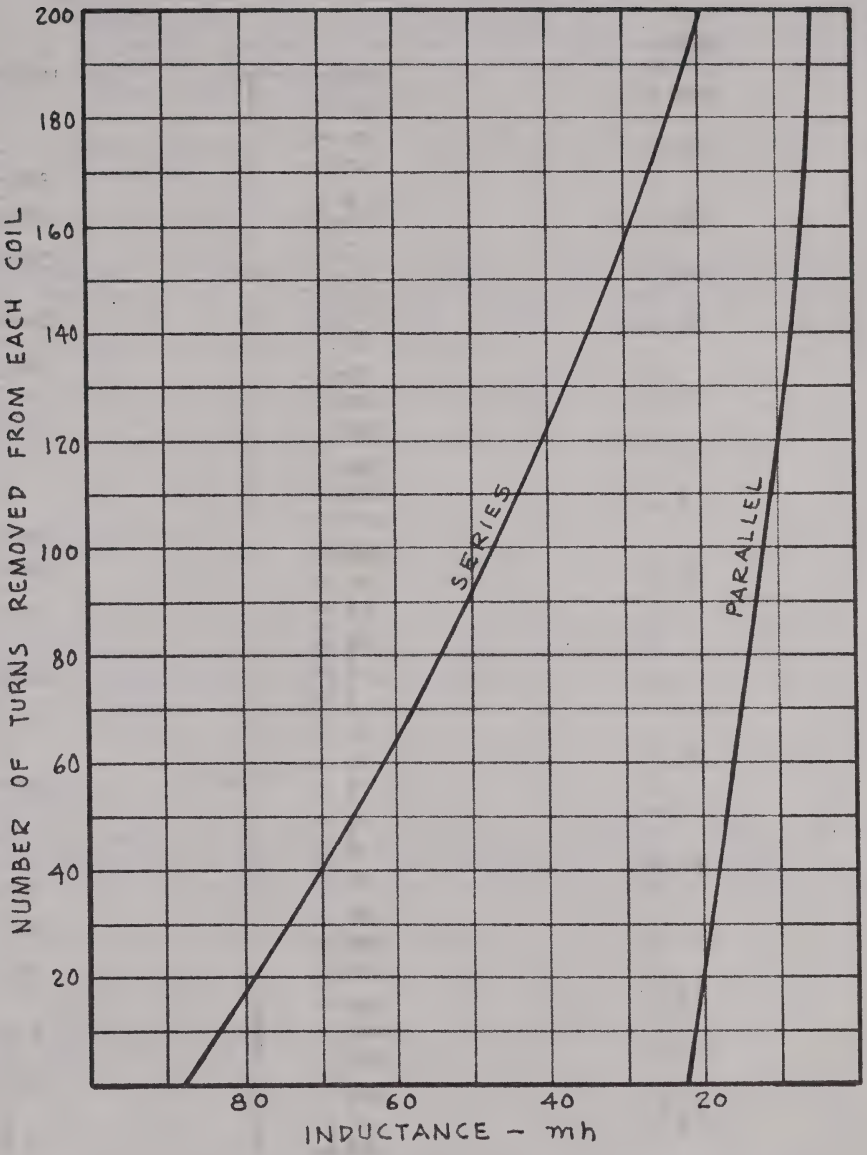
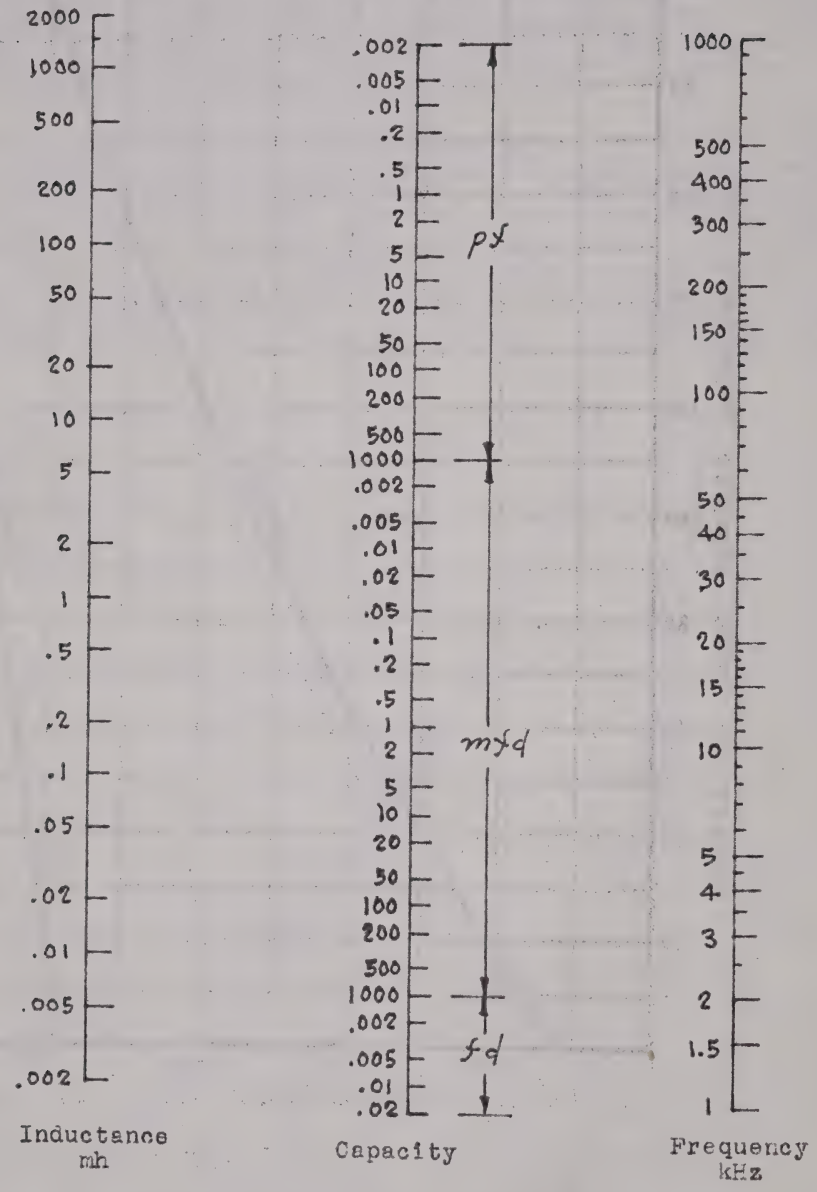


Fig. 4-27

38/32 mh Toroids

Inductance, Capacity & Frequency Chart



Draw a straight line between two knowns to find an unknown

Fig. 4-28

Ferrite Cores

The KEY to how effective a core is when contained in a coil field, is the core's permeability....All manufacturers of cores will state the permeability of their product, but many surplus cores may find their way into the hands of an experimenter and the permeability could run from 40 to 10,000....Quite a range !

Using some simple mathamatics, let us take a look at just what permeability is all about.

Three major factors are involved:-

P = The apparent permeability of a core....The effective permeability of a core will vary depending on the core penetration into the coil field and in the case of "Pot Cores" and "E" Cores, the air gap between the two core sections.

Lwo= Inductance of a coil without the core.

Lw= Inductance of a coil with the core (full penetration).

Therefor:-

$$P = \frac{Lw}{Lwo} \quad \text{or} \quad Lwo = \frac{Lw}{P}$$

The "Lwo" formula is useful when you wish to wind a coil knowing what the permeability of your core is and the inductance required....You can now use a coil table and wind a proper inductance, since coil table do not consider a core.

COUPLED COILS

Many experimenters get confused about the inductance values of coils when used in series or parallel and treat them like resistors....This is not the case with closely coupled coils with the windings aiding.

Again, we have three factors involved:-

Lt = Total Inductance

M = Mutual Inductance

L1 & L2 = Self Inductance of each coil

Therefor:-

In Series.... $Lt = L1 + L2 + 2M$

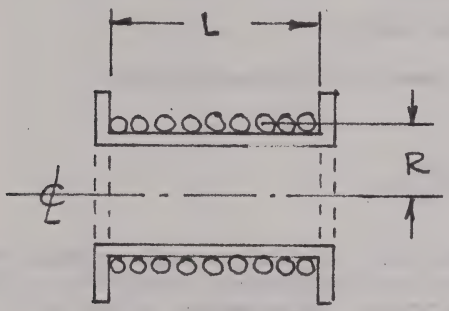
In Parallel.... $Lt = \frac{1}{\frac{1}{L1+M} + \frac{1}{L2+M}}$

Coil Winding Formulas

The following designations are used in the following formulas for single layer and multiple layer wound coils....Due to manufacturing tolerances and the type of insulation used, to determine the number of turns per inch which determines the coil length, I suggest that the experimenter wind some 10 or more turns of wire on a form and then measure the length used.

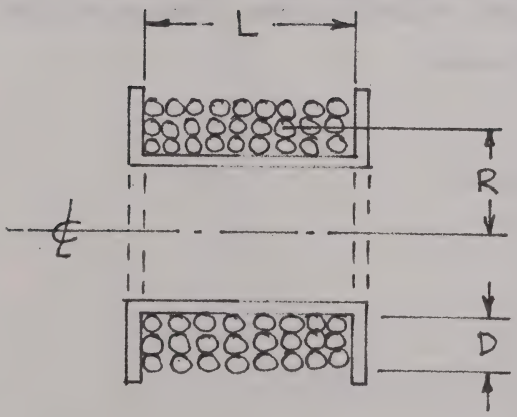
LS = Self Inductance in microhenries.
N = Total number of turns.
R = Mean radius in inches.
L = Length of coil in inches.
D = Depth of coil in inches.

NOTE:- Formulas are based on close wound coils.



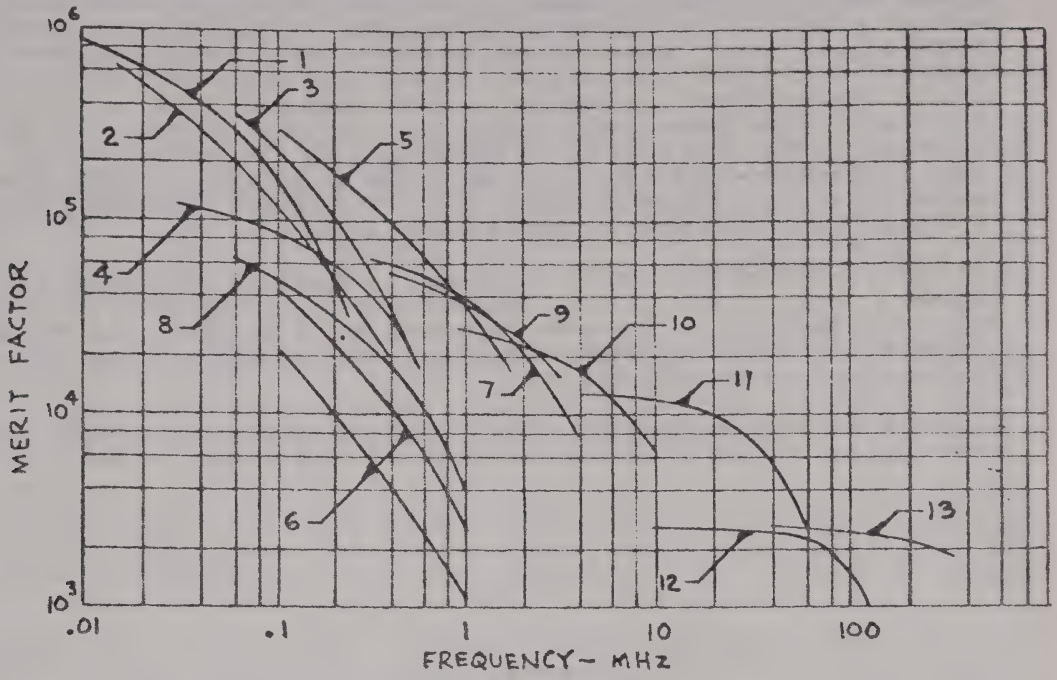
$$LS = \frac{(RN)^2}{9R + 10L}$$

$$N = \frac{\sqrt{LS\,(9R + 10L}}{R}$$



$$LS = \frac{0.8\,(RN)^2}{6R + 9L + 10D}$$

Merit Factor for Various Ferrite Cores Available.



The above graph is only offered as a guidance for what a Ferrite Core manufacturer may offer in a range of available permeability and core material....Magnetic ferrite cores are made from ferromagnetic oxides, alloyed with several types of oxides of bivalent metals, namely Nickle, Manganese and Zinc....For exacting applications, the core manufacturers specifications should be used.

Graph No.	Generic Type	Permeability (Initial)
1	Mn/Zn	6000 +/-
2	do	2500
3	do	2000
4	do	1500
5	do	1000
6	do	500 to 1200
7	Ni/Zn	850
8	do	500
9	do	190
10	do	125
11	do	35
12	do	12
13	do	7

In my Reception Chapter I describe a regenerative preamplifier, Fig. 4-3 and earlier in this chapter, a Test Oscillator Fig. 4-20 that requires a tap on the coil to obtain necessary feed-back for proper operation....In many cases, it may not be a comfortable coil winding operation to provide this tap, but there is another means that can be used that requires a secondary winding that can offer certain conveniences for the home-brew artist....Fig. 4-29 illustrates the arrangement....The Main Coil L1 is wound to suit the desired tuning range....The Feed-Back Coil L1a can now be wound over L1 with proper insulation and the turns adjusted to provide proper feed-back, which is almost impossible with a tapped wound coil.

The turns required for the Coil L1a can be equal to the Source Tap figures I show on Page 38 for "target range"....It is important that both coils be wound in the same "clock-wise" direction....If you have problems with obtaining regeneration or oscillation, reverse your wire connections to Coil L1a.

Coil L1a can also be used in other circuitry as a Coupling Coil and depending on the circuit, the coil may not be grounded at one end.

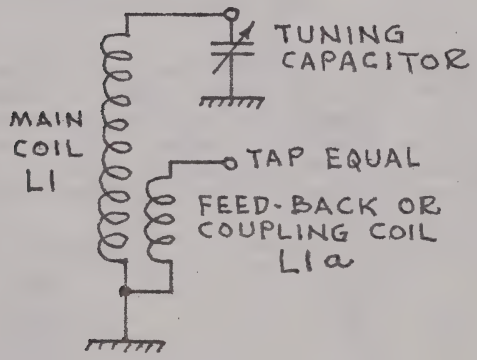


Fig. 4-29

TRANSMITTING

This chapter will not only describe transmitters for the nonlicensed communication bands, namely 160 to 190 kHz and 510 to 1600 kHz, but will also go into some detail with suggestions for the antennas used with same....A thorough review of the FCC Rules, Section 15 that is contained in the Appendix should be made before any transmitting operation is contemplated.

Since the start of my Scrapbook series 10 years ago, it has been hard to keep up with the advances in solid-state technology, particularly for someone not directly associated with the field such as in my case and I wish to thank some friends and fellow LOWFERS for their guidance and suggestions and untold hours using a soldering iron and bread-boarding....I hate to say how many of my solid-state devices have ended up in the "round file" !

I have always been interested in radio and got my Ham Ticket in 1935 and grew up in the "vacuum tube age"....In some respects, fooling with the tubes was fun....They took alot of abuse and if you pulled a boo-boo, chances are that you had another "crack at it"....Not so with a transistor, one mistake and "pfttt"....By-by baby !

Solid-state devices have changed transmitter design drastically....In the old days, a transmitter had to have a tuned circuit in every stage whereas today, using IC's the only tuned circuit required is the antenna coupling coil in the final amplifier and in the case of using a variable frequency oscillator (VFO), its tuned circuit.

However, for experimenters that are vacuum tube buffs, I suggest that they scrounge around and find one of the earlier editions of my scrapbook series that were highly vacuum tube oriented as to most active circuits....There are still many successful LOWFERS that use vacuum tube rigs and in some cases, hybrid transmitters using solid-state exciters and a vacuum tube final amplifier.

As to a transmitter design, most of your amateur radio handbooks are chock-full of low powered transmitter circuits and by using the proper inductance for L/C circuits, larger size RF chokes and higher value by-pass capacitors, they should be operable on the nonlicensed communication bands.

I will not go into any detail in this edition of my scrapbook for transmitters operable below 10 kHz....The FCC has no regulations on power input or antenna configurations below 10 kHz, but you must be aware, that any harmonics that may fall above 10 kHz will have to meet their field strength restrictions....In the mid '70s, I did some experimenting in the 8 kHz +/- range that showed promise for local communications but living on a 50 x 100 ft. estate, I just do not have the room for respectable antennas useable in this range.

So, again back to the "nitty grit"....Let us consider some practical designs for an efficient 160 to 190 kHz transmitter....First we have to consider the use of parts that are common as to availability and not expensive....There is nothing more frustrating than to read an article in a magazine on a super-dupper something or other and get all fired up, only to find you can't find or buy the "gimmick" !

An important point to consider is the type of frequency control used, and this involves the exciter....Crystals in the 160 to 190 kHz range are quite expensive and my experience has indicated that to be stuck on only several fixed frequencies can be very frustrating....On the Ham Bands, I have often been asked to move a few kHz one way or the other to get away from some QRM....On 1750 meters, you may be asked to move only a few hundred Hz....Quite a difference !

You must realize that the low frequency spectrum from 510 kHz to 10 kHz is no wider than the 80 meter Ham Band (3500 to 4000 kHz) 500 kHz. While the 160 to 190 kHz band is only 30 kHz wide, it still consists of some 6% of the spectrum, and not a bad "slice of the action" !

So to get down to brass tacks, considerable thought should be given the exciter and type of oscillator used for frequency control....By using the various types of the cheap IC Chips that can be used in the many types of frequency dividing circuits and in this case if crystal control is desired, the resonable priced high frequency crystals can be used....Many frequency ranges are still available on the surplus market....Another important point to consider in the divide by "X" circuits is the fact that if a variable frequency oscillator (VFO) is used, any instability or drift in same is lessened in the output circuit by the division factor....Also, since the VFO is not operating on operational (output) frequencies, it can run continuously and not affect reception and stability is improved.

In the 3rd edition of my scrapbook and in the Addendum, I describe a divide by 2 or 4 transmitter designed by Joe Bauer (W9WQ) and from mail received, it was very popular....It used surplus crystals that were plentiful at the time, but now hard to find....I describe an updated version of this transmitter with a VFO circuit and a VMOS final amplifier that should be of interest to the users of the original design....See Fig. 4-34.

Palomar Engineers, PO. Box 455, Escondido, CA 92025 is the only outfit that I am aware of at this writing, that offers a 160 to 190 kHz transmitter....It uses an exciter in the divide by 32 mode that is completely assembled with 120 v. ac power supply and the final amplifier uses a VMOS VN88AF and comes in kit form....For non-homebrew LF Buffs that may wish to try communications on 1750 meters, this package may be of interest.

I offer a review of this transmitter on pages 73 to 77 and also offer some convenience modifications as well as a simple inactive VFO plug-in unit that should be of interest to owners of the transmitter.

To wrap-up this phase of my introduction to the Transmitting Chapter, I hope the following text will provide interested experimenters with sufficient information to help put him/her into communications on the 1750 meter band....Communications is a "key stone" for the exchange of intelligence and the use of "radio" for same is only limited by your imagination.

Under the FCC Rules, we are forced to use low power and a very inefficient antenna so considerable thought has to be given to the final amplifier design and the means used to couple same to the antenna.

There are many circuits described in the various radio handbooks that use bi-polar transistors for RF amplification and I have tried my share, but I was never really satisfied as to performance compared with a vacuum tube until I ran into the Siliconix VMOS Power FET's. I have used quite a few of the devices and they appear a "natural" for a one watt final amplifier running at some 10 volts @ 100 ma.

I have tried tried the VN40AF, VN66AF, VN67AF and the VN88AF and I have noted very little difference in their performance and the only basic difference is their voltage rating of 40, 60 and 80 volts respectivily....A VMOS does not like "voltage spikes" in the Drain supply and care should be taken to avoid this possibility....The first VMOS I blew up, was when I tried to key the final amplifier....In the circuits I describe, the VMOS's behave like an old Class "B" Linear amplifier....With no drive, there is no drain current flow and this makes it ideal for providing a CW key circuit in the exciter.

The Radio Shack chain stocks a VN67AF with a price tag of $2.49 in their 1982 catalog and the types I mention above are all in a TO-202 Case....For experimenters that may desire a higher voltage rating than 60 volts, I suggest the VN88AF that has a rating of 80 volts and for the few cents extra involved, may be worth the investment, but it may be hard to find.

Siliconix have distributors scattered around the country, but many of them only deal with quantity buyers and may have a sizeable minimum order....Except for the VN67AF and some other FET's and IC's that the Radio Shack chain does not handle, I purchase my solid-state devices from Hamilton/Avnet, 10 Industrial Road, Fairfield, NJ 07006 (Tel. 201-575-3390)....They appear not to have a minimum order, but of course, sufficient postage should be included....A SASE or land-line call should get you the information.

Using a VMOS as a final amplifier, there are several choices as to providing Gate bias and means to couple the amplifier to the antenna. The following text will describe circuits that I have had reasonable success with and I can assure any reader that properly constructed, any one of these circuits should put you on the air.

A word of warning....If you use an RF Choke in the drain circuit, be sure that it can comfortably handle a 100 ma. current flow and it should offer minimal dc reistance, or OHM's Law will rear it's ugly head....Unfortunately, transmitting type RF Chokes are large and not compatable to mini-solid-state circuitry....I wind my chokes on small "E" core assemblies and they use less than 1/2 cubic inch of space @ a dc resistance of less than 3 to 4 ohms !

The following circuits can be used for guidance and combinations of the Gate bias and Antenna coupling schemes can be used.

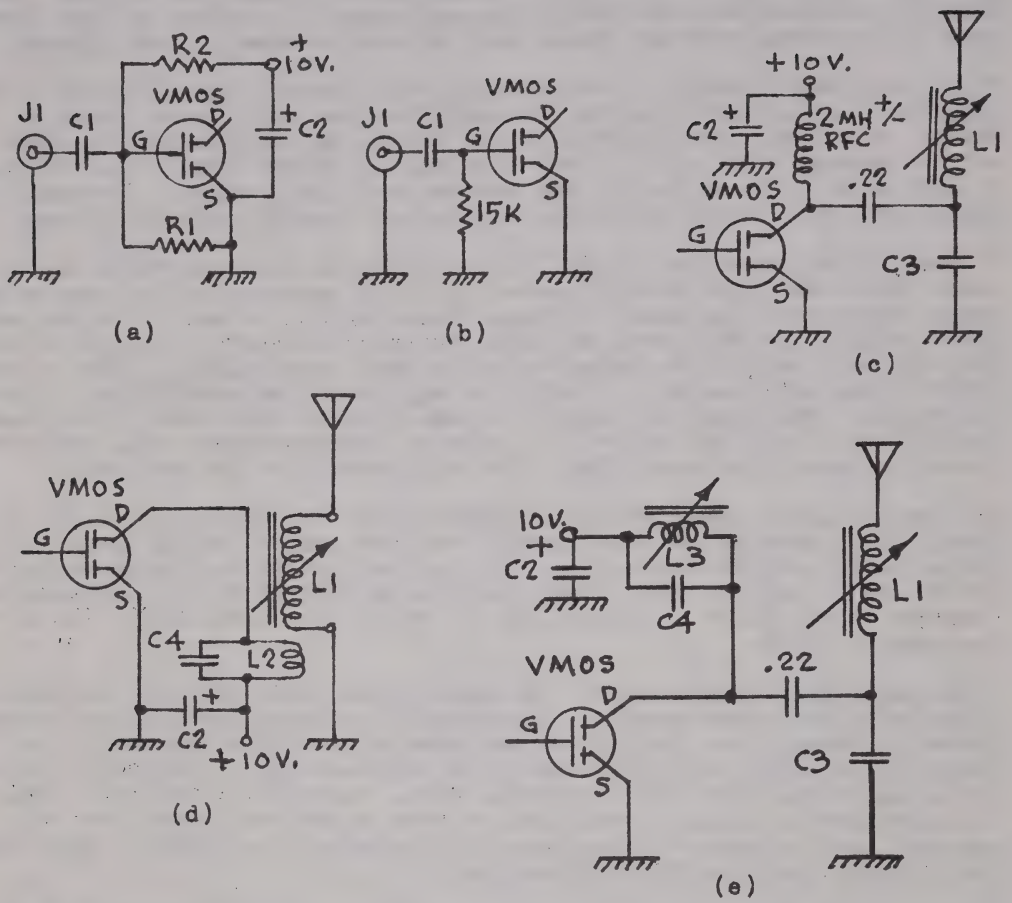


Fig. 4-30:- Diagrams (a) & (b) are suggested circuits for obtaining Gate bias....C1, the input capacitor value is not critical and I suggest .01 mfd....It can be eliminated if in the Exciter output.

Target values for R1 is 680K and for R2 4 meg....These values are not critical and I have used up to 2.2 meg. for R1 and 5 meg. for R2, but depending on the VMOS used, it may pay-off to experiment with these values for best efficiency.

Diagrams (c), (d) & (e) are suggested antenna coupling circuits that I have used and they all work and I will go into further details on same in this text.

One word of warning:- Any RF Choke used, if in the Drain circuit, must have a low dc resistance (Ohm's Law) since we are dealing with over a 100 ma current drain @ some 10 volts.

In circuits (a) & (b) the input connector "J1" is strictly a matter of preference and can be eliminated if the amplifier is adjacent to the exciter....Otherwise, use your favorite co-ax connector.

In testing out your final amplifier, you may discover in your own home that you interfere with TV or FM reception....In this case, I suggest that you try using a ferrite bead or a low value carbon resistor of some 150 to 220 ohms in the Gate lead and place as close as possible to the Gate.

I might mention for the record, that the VMOS's I refer to in this Chapter have a built-in protection for static-discharges that I do not show in my circuit diagrams for simplification.

Since the Gate bias only envolves a few cheap carbon resistors that an experimenter can fool with, the effectiveness of the final amplifier will depend on the efficiency of the coupling to your antenna, and I suggest a close review of the circuits I show in (c), (d) & (e) be made....No matter how you look at it, from here-on-in we are dealing with COILS !

As I mention in my Coil Winding Chapter, the "Q" of a coil is it's Merit Factor and normally, the higher the "Q" the more efficient the coil will be in a resonant circuit, particularly where there may be a sizeable current flow, as in our case +/- 100 ma.

However, lets look at the Antenna Coupling Circuits I show in (c), (d) & (e) and I will add my personal comments:-

First of all, I will have alot to say about the Antenna Coupling Coil (L1) further on in this chapter....Also, the by-pass to ground capacitor from +10 v. (C2) is normally 1 mfd., if AM modulation is contemplated by using a transformer in the Drain lead, I suggest reducing its value to .05 to .1 mfd.

In Schemes (c) & (e), capacitor C3 is in series with the Antenna Coupling Coil (L1) and its ground system and should be tuneable at the operational frequency....A target range for C3 is .02 mfd....The tuning of course is accomplished via L1....I have already made my comments about the dc resistance in the RF Choke in Scheme (c).

Scheme (d) is basically the same as used in the Palomar transmitter that I review in this chapter....The Drain circuit contains a broadband tuned circuit L2 & C4 that is a very high C to L ratio and this circuit is close coupled to the antenna coupling coil L1....Normally tuning is accomplished by the ferrite core in L1.

One of my favorite circuits is shown in Scheme (e) which is a combo of (c) & (d), but in this case I use a resonant circuit in the Drain (L3 & C4) using again High C to L ratio like (d) but I capacity couple the output to the antenna coupling coil instead of inductive, as I illustrate in Scheme (c).

So the next item on the agenda is Tank and Antenna Coupling Coils and some thoughts about seeking their efficiency.

While I find my Boonton 160-A "Q" Meter an immense help in weeding out various coils I have wound as poor or acceptable, I realize that there may be many experimenters that do not have access to a "Q" Meter and what can be done about it in a simple and inexpensive way.

Two "gimmicks" are required....A "Voltage Stick" and a "Dummy Antenna" should put you in business....The "Voltage Stick" consists of 8 to 10 NE-2 Neon Bulbs (Radio Shack #272-1101) soldered together and strung in series on a wood dowel about 12" long....Wrap the soldered connections between each bulb to secure same to the dowel with tape....At one end, solder a short length of flexible wire with a small alligator clip that can be connected to the antenna output of the final amplifier.

The "Dummy Antenna" is nothing more than a carbon resistor connected in series with a capacitor and is placed across the transmitter antenna output and ground....The resistor is 25 ohms (four 100 ohm 1/2 watt carbon resistors in parallel)....The capacitor should duplicate your vertical antenna's capacity to its ground system and have a minimum voltage rating of 600 volts....150 pf should be in "target range", but I use a 360 pf variable capacitor as it is interesting to note what an antenna's capacity vs. efficiency means in the output circuit.

So, let us look at the facts....Due to the FCC Rules we are dealing with VOLTAGE on the antenna and the "Voltage Stick" is a very helpful device....The more bulbs you can light up, the higher the voltage on the antenna and a stronger radiated signal....I have confirmed this on many occasions using a remote field strength meter....If I can't light up some 7 to 8 neon bulbs on the "Voltage Stick", back to the drafting board....Hi !.....Do not worry about current....If you have a good voltage indication on your antenna and are using one watt input to the final amplifier, the current will take care of itself !

Not to sound repetitious, but it appears that the "secret of success" is an efficient Antenna Coupling scheme and due to the voltage involved, a well insulated vertical antenna installation....However, we are still involved with the problem of an efficient Antenna Coupling Coil and let us review this critical item.

There is an old saying, that if you want to be "big" you have to think "big", and some LOWFERS follow this philosophy when it comes to antenna coupling coils....I have seen coils some 18" to 36" in diameter and up to 5 feet tall wound with heavy Litz wire and #10 copper wire, etc. I recently checked one of these massive coils for a friend of mine on my "Q" Meter and in an operational circuit and the "Q" was in the 500 range, yet in an operational circuit, I could light as many Neon Bulbs in my Voltage Stick with a ferrite "E" core assembly wound with 120 turns of 63/42 Litz wire that only used 4-1/2 cubic inches of space ? So for the average experimenter, let us get practical, and I suggest that you review my coil winding chapter for possible ideas.

Probably the simplest coil is to use a 1/2" diameter ferrite core and a coil wound on a close fitting form....The number of turns required

will depend on the permeability of the ferrite core and I suggest that nothing under 800 be considered and the turns can vary between 300 to 500 turns....Of course, tuning is accomplished by adjusting the core penetration into the coil field....Another point to consider is the fact that a short length inductance will make for very sharp tuning on the core penetration and is not desireable....The longer that you make your coil, the easier it is to "fine tune"....I suggest that you consider something along the lines of the "push rod tuner" Fig. 4-21.

Considering minimal space requirements, one of my favorite antenna coupling coils uses an "E" Core/Bobbin assembly that I described in the Dec. '81 issue of the LWCA's LOWDOWN....The assembly measures 2-1/2" wide x 1-1/2" deep and 1-1/2" high....The bobbin has 3 winding windows and requires only 120 total turns of wire....I use the "E" cores like a hinge with an 8-32 screw feed on one side....A SASE will get you the information.

So, to wrap-up this phase of the chapter, any effort put into an efficient antenna coupling coil will PAY OFF" !

The Palomar 1750 Meter Transmitter

To my knowledge, Palomar Engineers, Box 455, Escondido, CA 92025 is the only company that offers a 1750 Meter Transmitter and it complements their low frequency line consisting of a converter and a ferrite core loop antenna with built-in pre-amp.

Palomar wisely sent some prototypes of their transmitter to seasoned LOWFERS for our constructive criticism before offering same for sale. I will not go into any detail on the minor faults we found, but they have been corrected and the transmitter is an exceptionally fine performer....The basic solid-state design uses tried and proven circuits and has stood up to tests "under fire".

The transmitter comes in two packages, the Exciter and the Final Amplifier (Palomar calls the amplifier a "Active Antenna Matching Network)....The Exciter comes completely assembled in an attractive cabinet measuring 2-3/4" high x 7" wide and 7-3/4" deep....All controls are located on the front panel and the 120 v.ac power supply is built in....The front panel contains a crystal socket, off/on switch, two phono jacks for a key and RF output and a two terminal screw strip for +/- voltage for the final amplifier....There is also a potentiometer to control the voltage output to the final amplifier so that it can be set for one watt input.

The Exciter is basically a "signal generator" using IC circuitry that will divide the frequency determining device (in this case, a crystal) by 32....Thus, any crystal in the 5120 to 6080 kHz range will provide an output in the 160 to 190 kHz band....The Exciter is supplied with one crystal located about mid-band....However, crystals in this range are reasonably priced.

The Final Amplifier comes in kit form with a printed circuit board and all necessary parts....The coils are factory wound with Litz wire and the 1/2" ferrite core for tuning is included....Assembly is simple following the well written instructions and should not take more than one hour....The final amplifier is a VMOS VN88AF.

For experimenters that may wish to construct their own amplifier, I have been informed by Palomar that the exciter can be purchased as a separate item.

The amplifier should be located as close as possible to the base of the vertical antenna and in most cases, contained in a weatherproof housing....Coax cable is used to connect the exciter to the amplifier. The only inconvenience, which most LOWFERS are faced with, is the fact that if the operational frequency is changed, the amplifier has to be re-tuned.

As offered, the transmitter is useable on CW only and I highly recommend that any potential LOWFER start this way....Brushing up on your code speed never hurt a LF Buff and in some cases, may pave the way to help you get your Ham Radio license.

If you wish to use the transmitter on AM voice, I suggest that you try the following scheme....Use an audio output transformer with a voice coil secondary....Connect the primary in series with the plus (+) lead to the final amplifier....Feed the voice coil from the voice coil output from a small audio amplifier and you should be in business....If you have trouble obtaining sufficient modulation, reduce the 1 mfd. by-pass capacitor (from + to ground) in the amplifier to .05 to .1 mfd....There should only be a slight change in amplifier current drain with voice peaks and be sure to monitor your signal to be sure that you are clean of over-modulation splatter.

To conclude my review of the Palomar 1750 Meter Transmitter, I would like to mention some "convenience modifications" that I have made and pass them on for what they are worth.

1) I removed the phono jack used for the KEY and replaced it with a standard 1/4" shorting type of phone jack (Radio Shack #274-255). As the rig stands, a shorted phono jack has to be inserted to make the exciter operational....This change made the exciter compatable to my other communications equipment and only took a few minutes.

2) The exciter model I have used a double pole switch for on/off and only one side was used....I mounted a three terminal barrier strip to the rear apron and connected two of the terminals to the other half of the switch for external relay control....The third terminal was wired to the internal plus (+) 15 volt buss line providing a power source for external equipment requiring only some 20 to 30 ma. drain. The relay control in many cases is required for efficient transmit/receive operation, which is common in most Ham operations.

3) I hate to be "rock-bound" and wanted the flexibility of using an external variable frequency oscillator....Using the divide x 32 principle, any instability in the oscillator is lessened by 32 times....I fooled with many schemes and finally came up with a simple L/C plug-in unit that could be plugged into the crystal socket, See Fig. 4-33.

Fig. 4-31 and 4-32 are the circuit diagrams of the Palomar transmitter and I also note the minor modifications that I made.

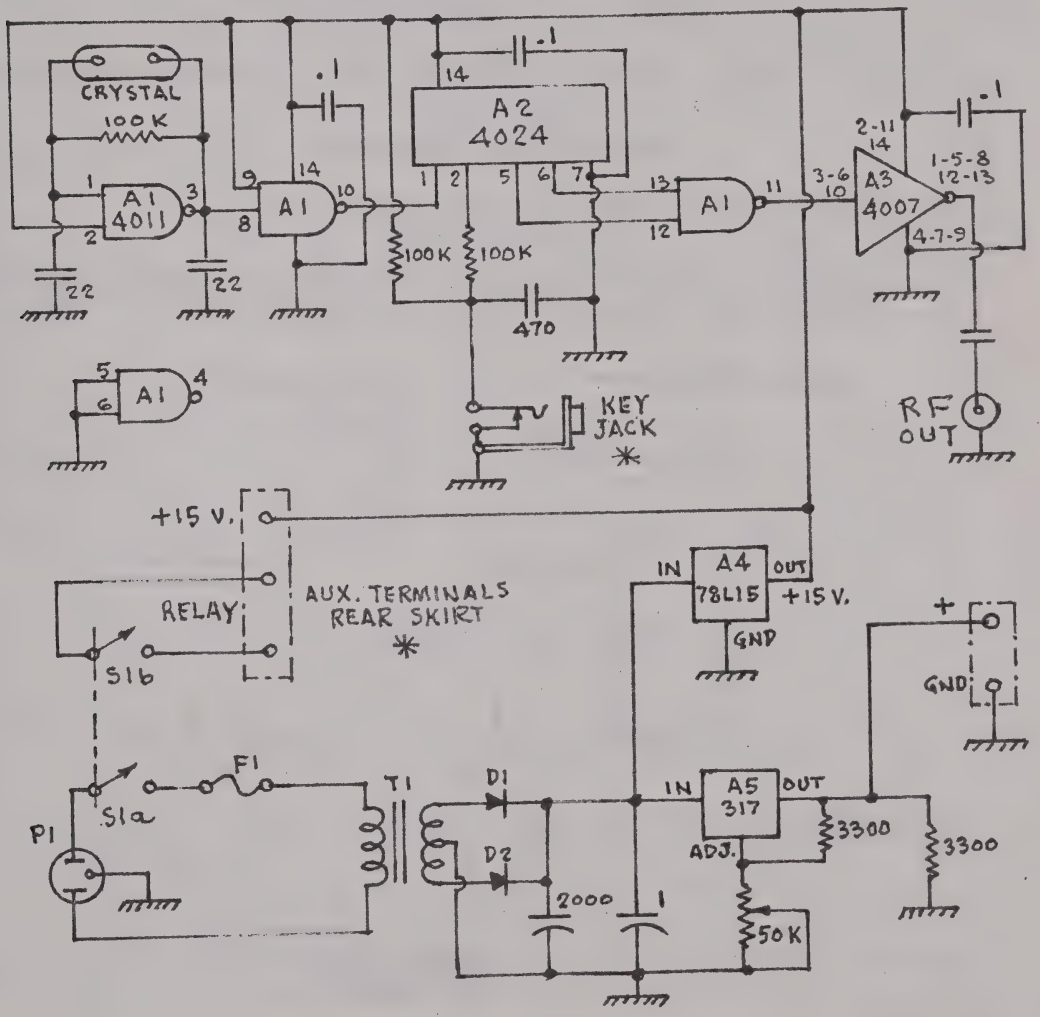
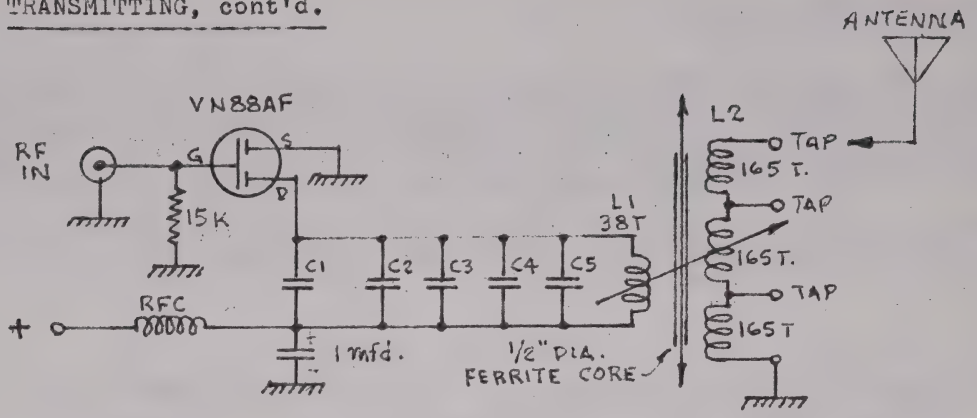


Fig. 4-31
Palomar Exciter Circuit Diagram
Note:- Asterisk indicates my modifications.



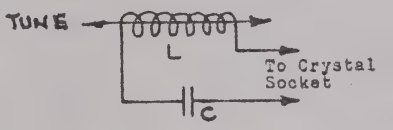
C1= .0027 mfd. C2 thru C5= .0068 mfd. Total approx. .03 mfd.

Fig. 4-32

Palomar Final Amplifier

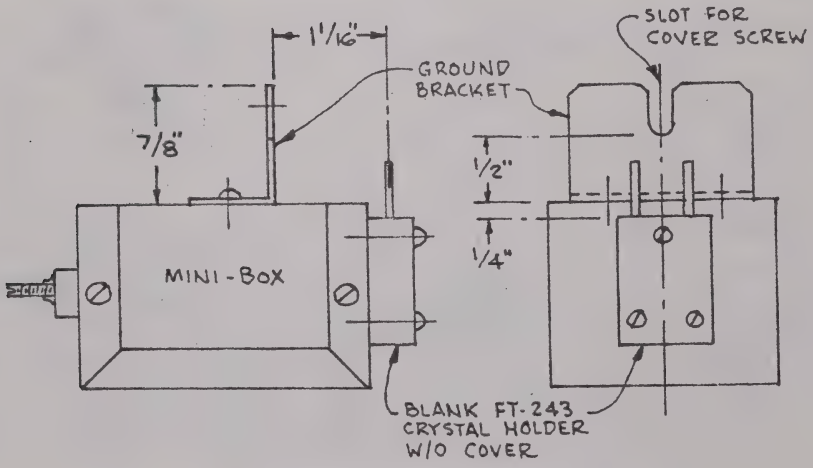
PLUG-IN VFO ADAPTOR FOR THE PALOMAR TRANSMITTER

The following is a discription of the simple VFO plug-in unit that I use with the Palomar transmitter....It is designed to plug into the crystal socket located on the front panel:-



CIRCUIT DIAGRAM

For component values see text.



STRUCTURAL LAYOUT

Fig. 4-33

The L/C network could not be simpler and only contains a slug-tuned coil in series with a capacitor that is capable of tuning through the 5120 to 6080 kHz range (divided by 32, this equals 160 to 190 kHz)....Tuning to a desired frequency is accomplished by adjusting the ferrite core in the coil field....I wound my coil on a 1/4" dia. slug tuned form with 60 turns of #32 enameled wire and used a 100 pf silver mica capacitor in series with the coil....Since this is a tuned circuit for frequency control any type of capacitor used should be of high quality as to stability....The actual capacity is not very critical, as the slug tuning covers quite a range.

My first experiment was to mount the coil and capacitor on a blank FT-243 crystal holder and was very pleased with the results, however, hand capacity near the coil did affect the frequency....I decided to mount the L/C assembly in a mini-box and provide proper shielding for the coil....Fig. 4-33 is the result....I used an aluminum mini-box, Radio Shack #270-235 for the enclosure and provided a ground bracket that will accept the front cover screw on the left hand side of the exciter cover plate....Please NOTE that neither side of the tuned circuit is grounded.

Tune your transmitter up with a crystal and check the frequency.... Then plug in the VFO unit and adjust the slug within the coil to zero beat the same frequency....By withdrawing the slug, you will now raise the frequency and by increasing the slug penetration into the coil, will lower the frequency.

UP-DATING THE DIVIDE x 2 or 4 TRANSMITTER

This 160 to 190 kHz transmitter was designed by Joe Bauer (W9WQ) and I described it in my 3rd edition and modification in the Addendum. According to mail received, it was very popular as it used surplus crystals that were available very cheap, years ago....This is no longer the story since crystals in the 320 to 380 kHz and 640 to 760 kHz range seem to have disappeared off the surplus market ?

So why not use a simple VFO or if on hand, a signal generator in lieu of a crystal....They will work and in the divide by 4 position, any drift in the frequency control is lessened by 4 times.

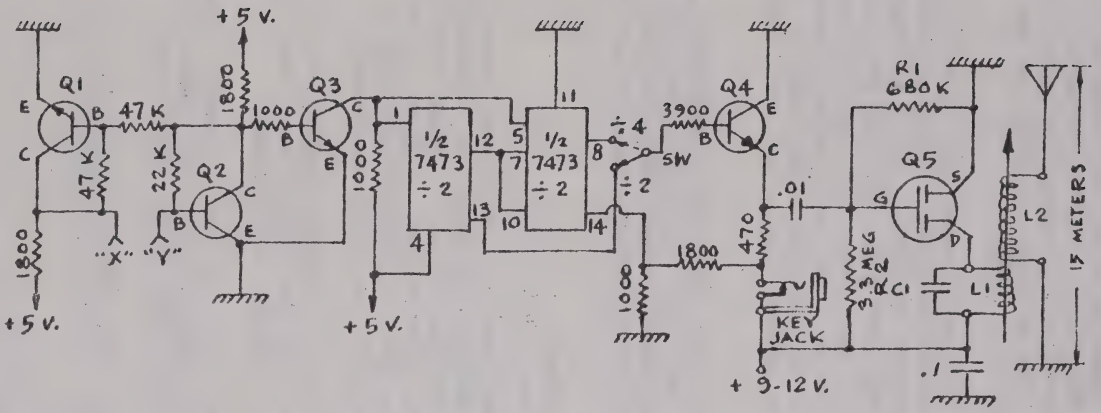
Furthermore, the oscillator can be left running continuously since it will not interfere with a received signal on the 1750 meter band. This is a tremendous help in self-excited oscillator stability.

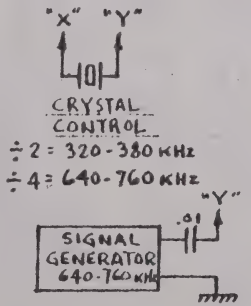
I also changed the final amplifier over to a VMOS and any of the circuits I describe for the use of same can be contemplated other than that shown.

Fig. 4-34 is the revised circuits suggested.

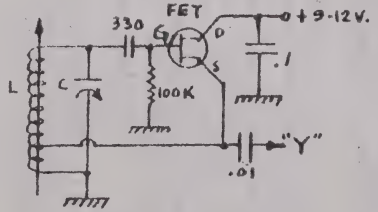
This data is included in this scrapbook for the LOWFERS that have constructed this transmitter.

The following text is dedicated to some more recent designs on the use of IC's in transmitter design.





VFO CONTROL



FET VFO

L and C are resonant within 640 to 760 KHz. I used a 1/4" diameter slug tuned form and wound 92 turns of #32 enameled wire with a tap at 30 turns. C is a compression padder of 350 pf maximum.

COMMENTS ON SCHEMATIC CIRCUIT

L1/C1 and L2 . . . See Text
Q1 through Q4 . . Most any NPN transistor 2N706 or equal.
Q5 . . . . . Siliconix VN67AF
R1 and R2 . . . . See Text
Target values and not too critical

Note: All grounds in all circuits are common to each other.

Fig. 4-34

THE UPDATED "DIVIDE BY 2 OR 4" - 160 TO 190 KHz TRANSMITTER

A Simple Divide-by-2 or 4 Transmitter Exciter

Just before wrapping up my text for the 4th edition of my scrapbook, I received a circuit diagram from Rich Brunner (AA1P), Foxboro, Mass. for another divide by 2 or 4 transmitter exciter using the CMOS 4000 series of IC's, Nos. 4049 & 4027 and available at a Radio Shack....I have not had the time to duplicate this circuit, but Rich is one of our pioneer LOWFERS and quite knowledgeable as a LF Radio Buff.

Using this circuit, and as I mention previously, the crystals in the 320 to 380 kHz and 640 to 760 kHz range are getting hard to find, but there must be still thousands of these around and you may have to do some scrounging around to find a supply ?

However, I see no reason why an external VFO as I suggest for the other rig, Fig. 4-34 or possibly the Palomar transmitter Fig. 4-33 may be used in lieu of crystal control.

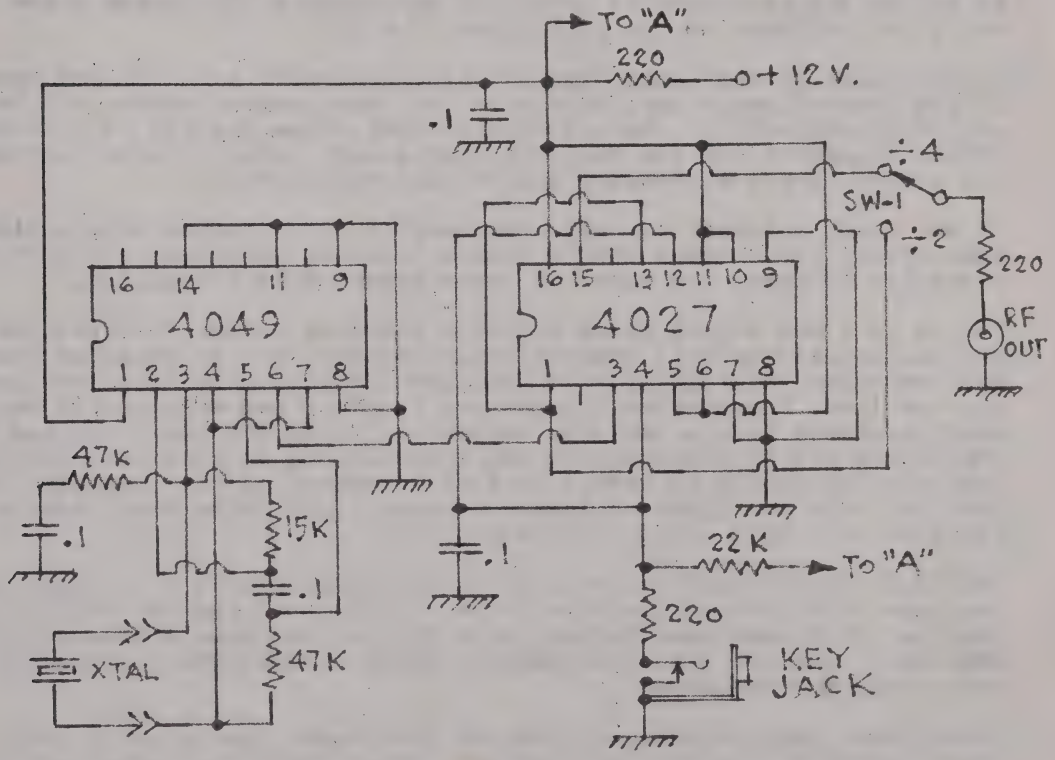


Fig. 4-35

Double Sideband Voice Adapter

I realize that there are many potential LOWFERS that would prefer to use voice on the 160 to 190 kHz band in lieu of CW and I felt that the simplest solution was to use double sideband and make an adapter that could be placed between an existing exciter and final amplifier....There are many circuits shown in the radio handbooks for generating a DSB signal and I tried breadboarding many of them with various stages of success, but none of them really "filled the bill".

Walt Glazar (W3WI) sent me a suggested circuit using a CMOS 4016 and it showed immediate promise....After some breadboarding and further communications with Walt, I finally ended up with a DSB adapter that I was looking for....The circuit is shown in Fig. 4-36.

The cost should be minimal and even without a well stocked junk box, I see a cost of under $15....CMOS 4016's are advertised for well under a dollar....In fact the only complicated part is the input transformer L1/L2 that should be resonant at the operational frequency and a center tap in the secondary is essential to obtain a 180 degree phase shift to the input of the 4016 (pins 12 & 13).

Power should be available from existing equipment and most any type of low powered audio amplifier with an 8 ohm speaker output can be used for modulation....Do not expect Hi-Fi voice quality on 1750 due to the nature of DSB and the fact that a well tuned 15 Meter antenna has a very narrow bandwidth, but it is intelligence !

It may be of interest to note that many of your popular single sideband transmitters start with a double sideband generator and then thru selective filters, the upper or lower sideband is attenuated.

Tuning in a DSB signal takes a little practice on the low frequencies and the proceedure will greatly depend on the type of receiver that you are using and stability is most important....Most receivers useable on these frequencies should have fairly sharp selectivity and many receivers have a variable control on their BFO and I suggest that the BFO be set at mid-position and when zeroing in on a DSB signal, that the BFO tuning be varied to take advantage of the receivers bandpass to favor the upper or lower sideband....It takes some time to get familiar with this , but it is worth it.

Push-Pull audio input is required to the 4016 (pins 1 & 11) and most any type of PP output transformer to a voice coil can be used, but I realize (as I mentioned before) that you may not have a sizeable junk box and I have had excellent results using a Radio Shack #273-1380 audio output transformer.

Audio power requirements are minimal and I have used a small Radio Shack 200 mw #277-1380 amplifier and it can "kick the pants" off the rig....Be sure to monitor your signal when operational and use the least audio power as necessary for best voice quality and most important, minimum band width.

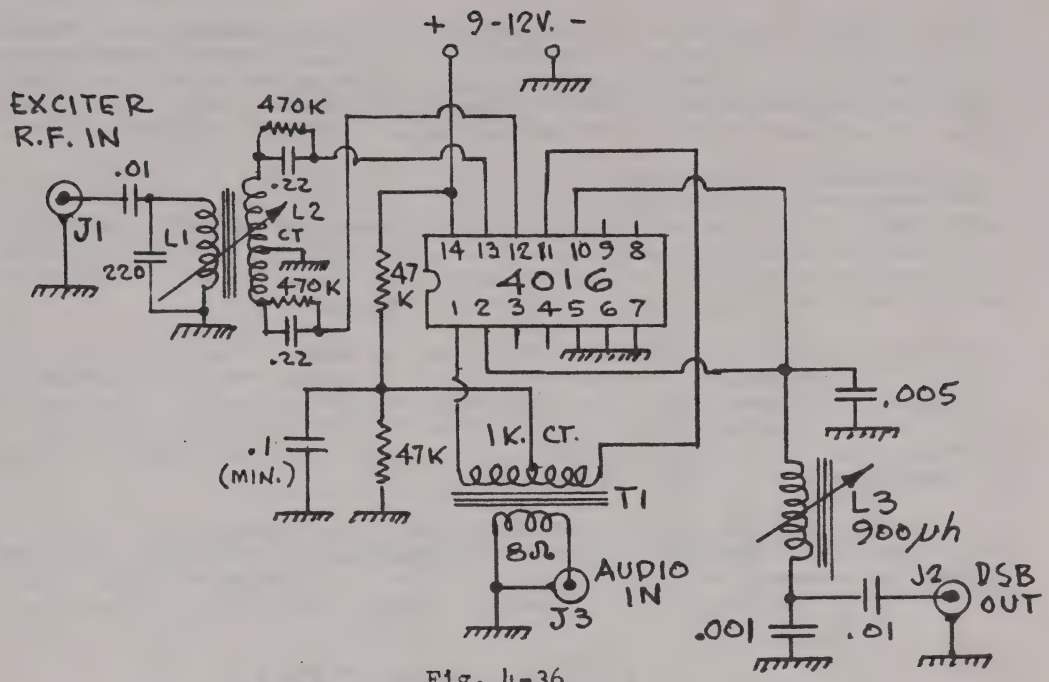


Fig. 4-36

General Notes:-

The input and output capacitors (.01 mfd.) can be eliminated if in the exciter or final amplifier.

The input and output jacks/connectors (J1 & J2) are a matter of preference and compatability to existing equipment.

The tuning of the input coils (L1 & L2) and the output coil (L3) is rather broad, yet by adjusting the inductance, voice quality can be improved....I used small "E" Core Bobbin assemblies that take up about 1-1/4" cubic inch of space and wound 140 turns for L1 and 300 turns, center tapped for L2 using #32 en. wire....For L3 I wound 52 turns of #22 en. wire....I can make these assemblies available and a SASE will get you the information.

For a "one shot" deal, I suggest the parts be mounted on a 12 spaced piece of perforated board available at any Radio Shack....The size will depend on the space required for the major components and the resistors and capacitors can be fitted in between.....Anyhow, I suggest that you make a study of part placement before the assembly.

Too conclude, I have used this adapter between the Palomar exciter and final amplifier and many other homebrew rigs I have constructed with excellent performance.

While I highly recommend the use of the VMOS FET family as a final amplifier, if you have your own favorite bi-polar transistor or op-amp circuit, by all means use it....We can consider that the final amplifier is the "muscle" of a transmitter, then in the same thinking, the exciter is the "brains" and should be given some thought.

Simple Divide by 2 Exciter

Walt Glazar (W3VI) also sent me some interesting exciter circuits that use the CMOS 4000 series....The simplest uses a CMOS 4047 and the circuit is shown in Fig. 4-37 and is VFO controlled and should be used with a voltage regulated power supply.

Output to drive the final amplifier can be taken from pins 10 or 11 and it is interesting to note that these outputs are 180 degrees out of phase....Either output can be used, but if the exciter is used with the DSB adapter (Fig. 4-36), pins 10 & 11 are directly connected to pins 12 & 13 on the CMOS 4016....In this case, the center tapped RF transformer (L1 & L2) is not used.

The VFO circuit (L1/C1) uses a very high C to L ratio and quality parts should be used with sturdy construction....Resonant frequency should be between 320 to 380 kHz....I used a slug tuned form with 150 turns of #32 en. wire....Tuning is accomplished with the slug.

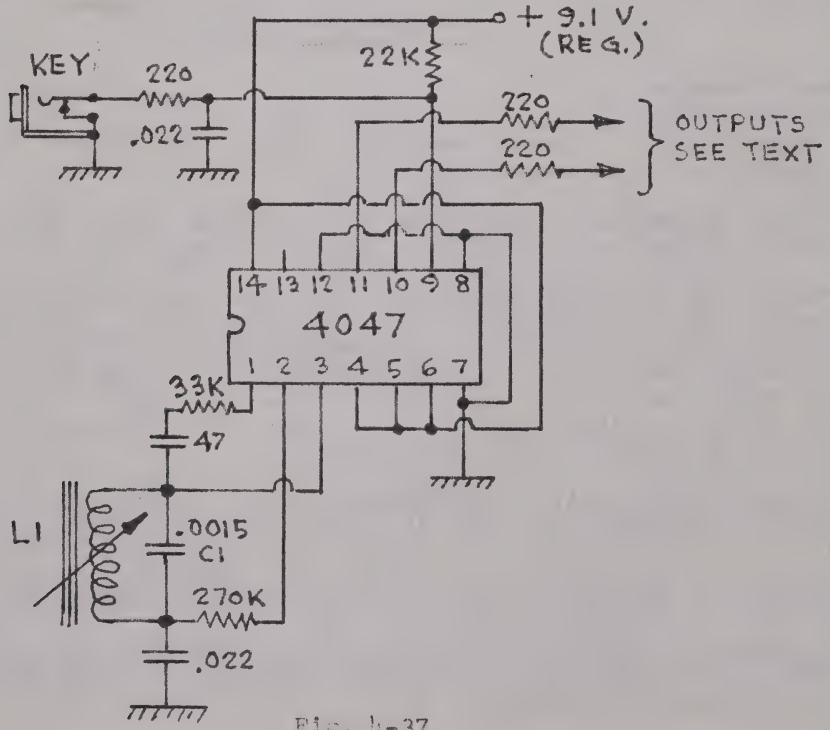


Fig. 4-37

High Efficiency Divide by 2 VFO Exciter

This design uses a 4011 and a 4013 and both are available at a Radio Shack (part nos. 276-2411 & 276-2413).

It provides a 90 degree conduction angle output and will drive a final amplifier to the utmost in efficiency...With only one watt to play with, this is an important point to consider in any transmitter design....See Fig. 4-38.

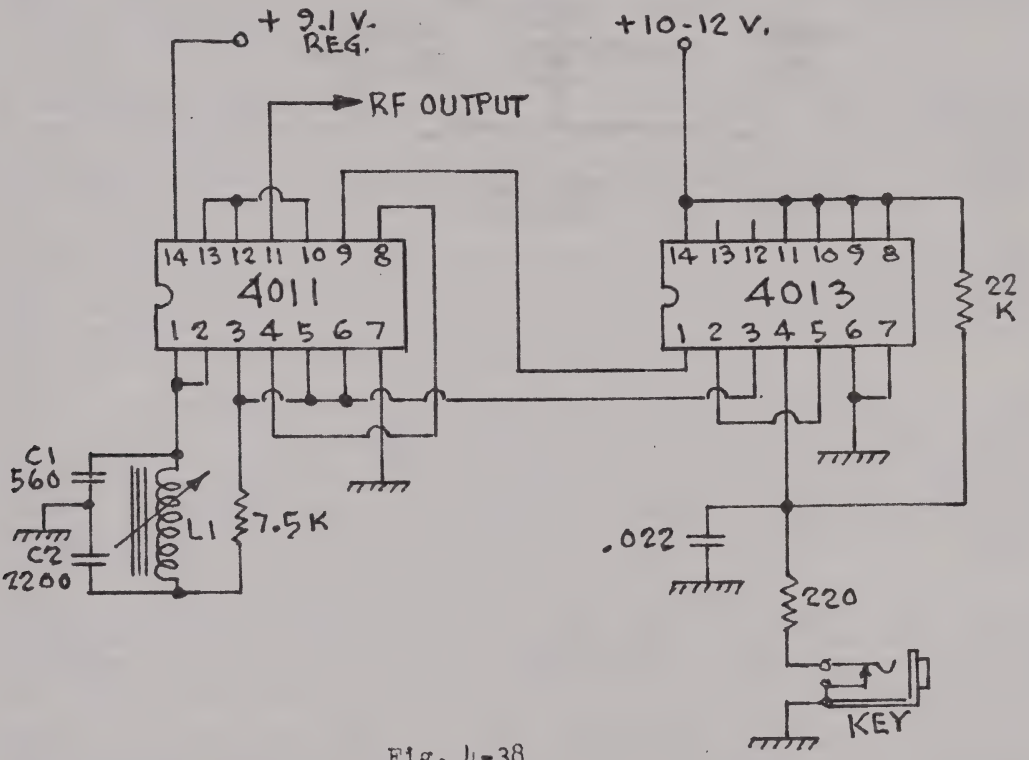


Fig. 4-38

Here again, quality components and sturdy construction should be used for the VFO tuned circuit (C1, C2 & L1)....I used 200 turns of #32 en. wire on a 1/4" dia. slug tuned form....The number of turns will depend on the permeability of the core material, so I suggest you add more turns, since it is easier to remove turns than add them....Tuning is accomplished with the slug adjustment.

TRANSMITTING, cont'd.

The simplest means to stabilize the voltage supplied to the VFO circuits I describe herein is with a 1N4739 9.1 volt, 1 watt Zener Diode (Radio Shack #276-562)....See Fig. 4-39.

The size of resistor "R" will depend on the supply voltage and the load drain current....Try 220 ohms to begin with.

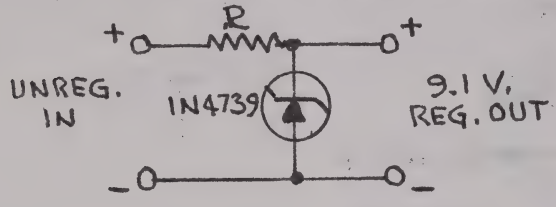


Fig. 4-39

510 to 1500 kHz

This frequency range includes our AM Broadcast Band and the FCC permits the operation of a nonlicensed transmitter with a power input limitation of 100 milliwatts and an antenna length of 3 meters. See the FCC Rules, Subpart D, Section 15.113 and also Bulletin OCE 12 that are contained in the Appendix.

While a 100 milliwatt transmitter with an antenna less than 10 feet long does not sound like it will make much of a "dent" in the high powered BC Band, my experiences indicate that in can be used for serious communication purposes.

BC Stations are separated by even multiples of 10 kHz....This leaves a small gap between stations of odd multiples of 10 kHz....Many are forced to reduce power at night and there are also many stations that do not operate 24 hours a day....This is strictly an area situation and anyone considering operation on this band should check his/her local situation and select the clearest frequency possible.

I also suggest that operation be considered within the higher frequency end of the band, since the mini-antenna will be somewhat more efficient than the lower end of the band....I have two crystals at 1575 and 1585 kHz and using the transmitter I will describe, I have been copied "Q-5" at some 18 miles using CW.

As to the transmitter design, there have been many "QRP" solid-state rigs described in the various radio ham publications and most any of these designs could be used with proper L/C tuned circuits....I have received reports that some experimenters have used the International Crystal Manufacturing Co. (10 North Lee, Oklahoma City, OK 73102) OX-LO Oscillator and the PAX-1 RF Power Amplifier with the coils wound for proper inductance for the BC Band.

The transmitter I describe in Fig. 4-40 grew like "Topsy" after many breadboard layouts using various oscillator and final amplifier types, scrounged from many reference articles and it proved out to be a very dependable performer.

Since we are dealing with a crystal controlled transmitter working into a fixed length antenna, after initial "tune-up", access to the tuning controls is not an important factor....I mounted my parts on a small piece of perf board and placed same in an "upside-down" coffee can to provide a weather-proof enclosure....The transmitter enclosure and base insulators for the 3 meter antenna were placed side by side on a wood board....For the antenna, I suggest the use of 6" diameter galvanized stove pipe and solder the joining sections and then bolt 3 angle brackets at the bottom of the pipe and use 3 stand-off insulators to support same....Paint the pipe with a good rust inhibitor paint and the final color is strictly a matter of cosmetic appearance to keep the neighborhood happy....Hi !....I mounted the basic assembly on top of a 4" x 8" x 16" cinder block and I can move it around at will....My "QRP Portable" ?

510 to 1600 kHz

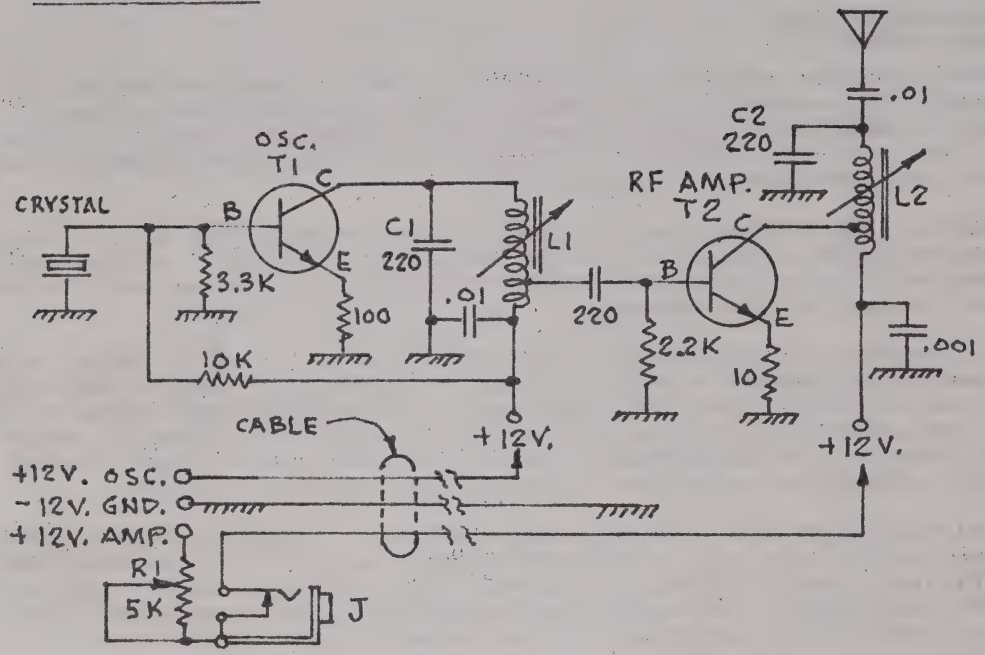


Fig. 4-40

Simple Transistor BC Band Transmitter, description:-

L1, L2....Target value is 70 uh....120 turns of #32 enameled wire wound on 1/4 to 5/16" dia. slug tuned forms....Provide a tap at 15 turns from + 12 v. end of coil.

C1, C2....Target value 220 pf....If slug does not provide proper tuning range, substitute mica compression padders 380 pf (Arco-Elmenco #465, or equal).

T1, T2....2N706 or equal NPN transistors.

Crystal...I use surplus FT-243 types (1575 & 1585 kHz)....If you order a new crystal, I suggest that you send the circuit diagram along with your order for proper calibration.

J.....Key jack....If AM Modulation is desired, I suggest that an audio output to speaker transformer be used....The high impedance primary is connected to the jack....The voice coil output from any low powered amplifier can be connected to the voice coil winding....This is basically a form of link coupling.

IMPORTANT

When the transmitter, with antenna connected is operational, the voltage and current drain to the final amplifier should be checked and R1 should be adjusted to provide 100 mw input....When using AM, please monitor your transmitted signal to be sure that you do not over-modulate with associated splatter, etc. that could interfere with a neighbors receiver.

The 160 to 190 kHz Antenna

Now that we have covered in some detail the Brains (exciter) and the Muscle (final amplifier) of a 160 to 190 kHz transmitter, we have to consider the "gimmick" that delivers the "PUNCH"....ANTENNA !

My personal experience and a fact confirmed by most successful operational stations (LOWFERS) is that the 15 meter antenna has to be a vertical....Due to the high voltage encountered on the antenna, considerable thought to it's installation should be considered as to proper insulation from all structural supports....While the power involved may not be considered lethal, it may not be a bad idea if there are young children in the area, to provide a barrier at the antenna base to prevent accidental contact with an operational antenna....I also suggest that before you erect your antenna that you take a sketch of your proposed installation to your town or city engineering office to be sure you are not violating any State or local codes. My experience indicates that most codes involve roof mounted antennas so be sure that the code official understands that you are talking about a ground mounted antenna.

Putting up a 15 meter long stick may sound like a simple task, but don't be fooled as it is not as simple as it sounds and should command some practical engineering thinking....Even a light weight antenna falling down during a high wind can cause serious personal injury or property damage.

Since the FCC includes the length of a transmission line in the Antenna length, this precludes for all practical purposes that the final amplifier should be located as close as possible to the antenna base. I still feel however, that a length of co-ax cable grounded and non-radiating acting as a "link coupling" between the final amplifier and the antenna coupling coil can not be considered a true transmission line in all respects, but here again we are dealing with interpretation of the rules.

The rule also only defines "length" not diameter or width and this is something to think about....The FCC is on record that they would consider an antenna taking up a 15 meter cube as a no-no....Interpretation again and I guess that you have to let your conscience be your guide....Just don't abuse the power limitation or field strength restrictions and be clean of harmonics that may fall out of the band.

The material used for the vertical is a matter of choice, cost and availability....Probably the most popular is the telescoping TV mast sections that come in 5 and 10 ft. lengths....If these are used, I suggest that the telescoping sections be secured structurally and electrically with self-tapping stainless steel screws.

There is also a wide variety of hardware for the sections available for guying, etc.

The 160 to 190 kHz Antenna, cont'd.

The location of your antenna is strictly a matter of property limitations and the building arrangements....If you have an acre of open space, you have it made....Locate your base insulator, guy line anchors and with a few friends to hold the guy lines, you are in business....However many LOWFERS may fall into my category....A 50 x 100 ft. lot is considered a sizeable estate in P.P.B. and by the time you deduct my house, two car garage and black-top drive, there is not too much open space left....The logical solution was to mount the antenna at a side of my house.

Another important point was the fact that I wanted to be able to put the antenna up or down without outside help....After a few near disasters, I finally worked it out and will pass it on for what it is worth.

The first item required was a stand-off structural support mounted on the roof eave siding providing good insulation for the antenna....I finally ended up with the support as shown in Figs. 4-41 & 4-42...The angled pipe supports can be mounted vertical, horizontal or at an angle depending on the construction of the roof eave.

I dropped a plumb-line down from the centerline of the antenna support and this located my base insulator....Along side of the base insulator assembly, I drove a 10 ft. length of 1/2" galv. pipe into the ground....This pipe serves two purposes....The first is obvious, a ground connection and the other is to serve as a fulcrum for a hinge assembly to permit me to raise the antenna.

The hinge is a simple clevis that can be made from a heavy duty door hinge....Your local welding shop can add a 6" to 8" long rod at one blade to fit the I.D. of the ground pipe....A 6" to 8" long piece of pipe that will fit the I.D. of the antenna tube is welded to the other blade.

I assemble my antenna on the ground plugged into the clevis hinge that is engaged into the ground pipe and properly dress the guy lines....A ladder is placed alongside of the antenna support on the far side and of course I remove the antenna securing strip....I then walk the antenna up and engage it in the support insulator....Then with some hand pressure on the antenna I climb the ladder and loosely secure the antenna with the secure strip....The antenna is now raised from the clevis hinge and lowered on the base insulator....The guy lines are now secured and the securing strip is made a fit to the antenna at the eave support....Hook up the rig and you are in biz !

To lower the antenna, I use the reverse proceedure and I have found that this scheme is quite effective for my situation.

160 to 190 kHz Antenna

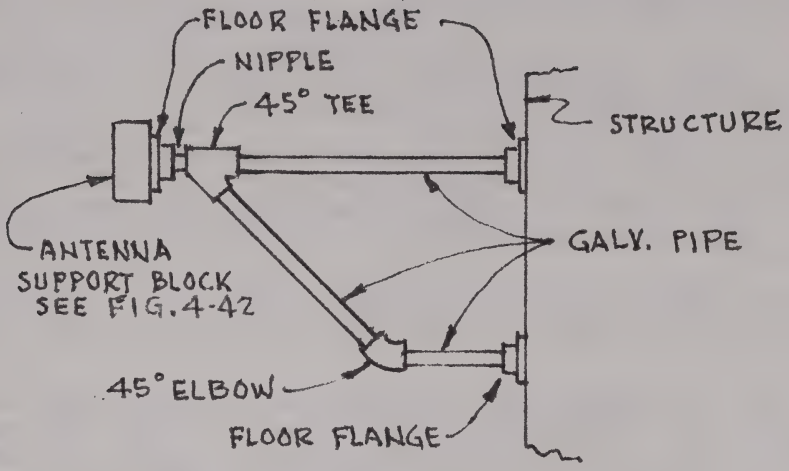


Fig. 4-41
Suggested Antenna Support

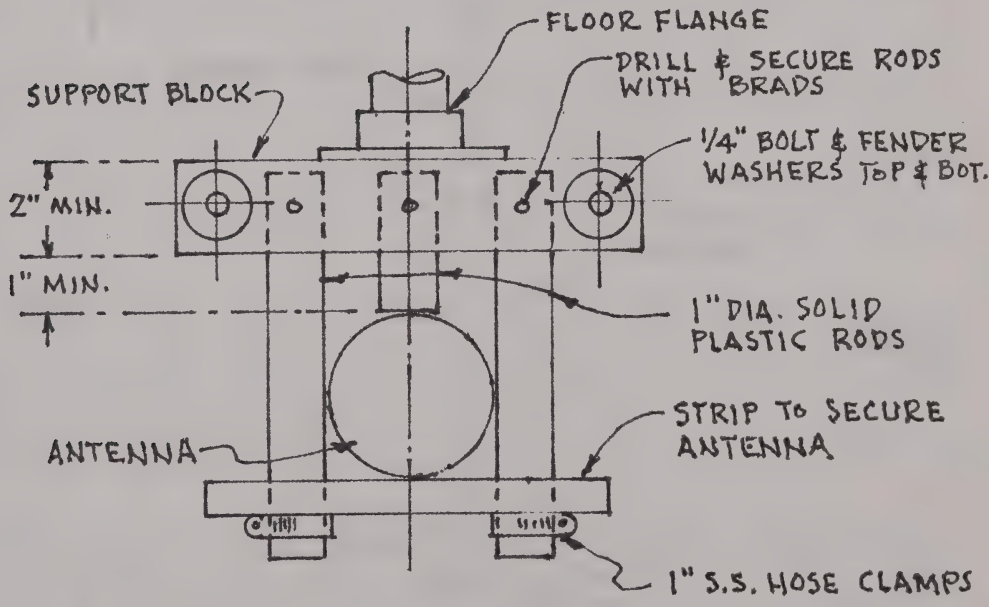


Fig. 4-42
Antenna Support Insulator

The 160 to 190 kHz Antenna, cont'd.

There is no doubt that the larger effective diameter that the vertical antenna exhibits, the greater distributed capacity to its ground system will be obtained, and this is desireable.

I have received many letters from my scrapbook readers suggesting all kinds of "bird cage", etc. assemblies and all I can say, is that I wish I had a "sky hook" up about 60 ft. with a rope and pulley so I could try out some of these schemes....Face the facts !....We have to be practical.

The normal 15 meter high vertical antenna will require guy lines, and why not use these lines to increase the antenna's capacity to it's ground system ?

While I hate copper-weld wire, it can be used for the guys and another scheme is to use a good grade of plastic rope and tape a copper enameled wire to same for the guys....The idea of course, is to bond the wire to the antenna at a reasonable height and then at the bottom end secure same to structural supports with egg insulators.

Using this arrangement it should provide a noticeable increase in the antenna's capacity to the ground system....See Fig. 4-43

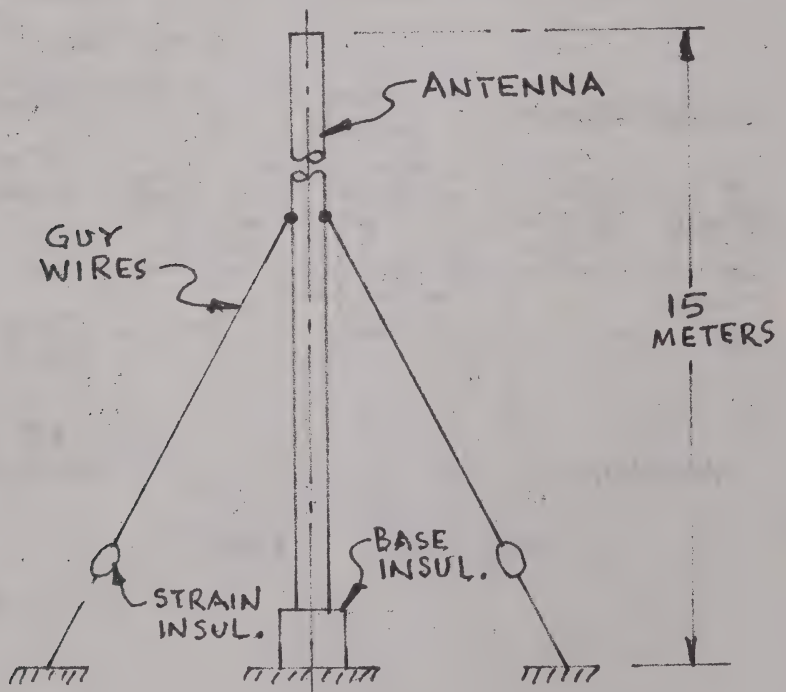


Fig. 4-43

Not to scale

To wrap-up this transmitting chapter, I would like to conclude with some random facts and thoughts:-

For LOWFERS that are licensed radio amateurs and really like to fool with antennas, raising and lowering 50 ft. long configurations can be quite a task....If we scale down the Frequency/Length 10 to 1, we end up with a 5 ft. antenna that is close to our 160 meter amateur band.

While propagation on 160 meters is not the same as 1600 meters, it is easier to experiment with a 5 ft. long antenna than 50 ft.

Using a remote field strength meter and inlisting the aid of some area friends, efficiency of your experimental endeavours can be easily confirmed.

Not to sound like a phonograph record in a groove, I still feel that the use of Litz wire for any final amplifier and antenna coupling coil is worth the bother and cost....A SASE to Magnet Wire Inc., 112-01 Northern Blvd., Corona, NY 11368 (Phone 212-651-0900) will get you available stock sizes and prices.

In any type of wire, always ask for the directly solderable type of enamel insulation....If not, you have to strip the insulation on each strand....In this case, I suggest that you try GC Electronics "STRIP-X"....I also suggest that you use the "STRIP-X" in the open air or you will smell-up your shack for a week !....Phew !

By all means, really digest my coil winding chapter since the final amplifier tank and antenna coupling coils determine the efficiency of getting the most of one watt input into the antenna.

Using a voltage stick or remote field strength meter, check the voltage on your antenna, or field strength reading in both wet and dry weather....If poor in wet weather, you have an insulation problem and it should be corrected.

The ideal situation is to have your antenna mounted over a good ground plane....When space permits, many LOWFERS use ground radial wires that are connected to ground rods....Another scheme is to lay a mat of galvanized chicken wire around the antenna on the ground....Mow the grass as short as possible and secure the chicken wire with hairpins made from old wire coat hangers....Of course the chicken wire should be electrically bonded to ground rods....After a few weeks, the grass will grow and you woun't even know that the ground-plane exists.

If you can afford a few bucks, I suggest that you get a copy of the Engineer's Notebook written by Forrest Mims III and available at any Radio Shack store....It contains many interesting facts and circuits applicable to this phase of a hobby....The divide by "X" IC circuits are most interesting.

I have not described any power supplies in this scrapbook because they are such a common item and well covered in most any radio handbook.

For any experimenter using solid-state devices, I find that a variable voltage power supply is almost a necessity and well worth the investment....The circuit used in the Palomar transmitter, Fig. 4-31 can be considered.

An excellent source for a power transformer is an old defunct black & white tube-type TV set....The filament windings should be good for quite a few amperes....The high voltage secondary is not used and I suggest that a 250 K, 1/2 watt resistor be placed across each half of the HV secondary....Be sure that this area is well insulated to prevent the possibility of a shock.

I would like to call your attention to FCC Rule 15.113 concerning a home-brew transmitter....The following certification is required:-

> I have constructed this device for my own use. I have tested it and certify that it complies with the applicable regulations of FCC Rules, Part 15....A copy of the measurements is in my possession and available for inspection.
>
> _____ _____
> Signature Date

Power input is measured for the final amplifier ONLY....Not the entire transmitter (exciter)....It is strictly a matter of the current drain and voltage using Ohms Law....Volts X Amperes = Watts.

Fig. 4-44 is a graph that can be used as a quick reference for a one watt input as to voltage vs current.

For 100 milliwatt input, reduce the current values to 10% of those shown.

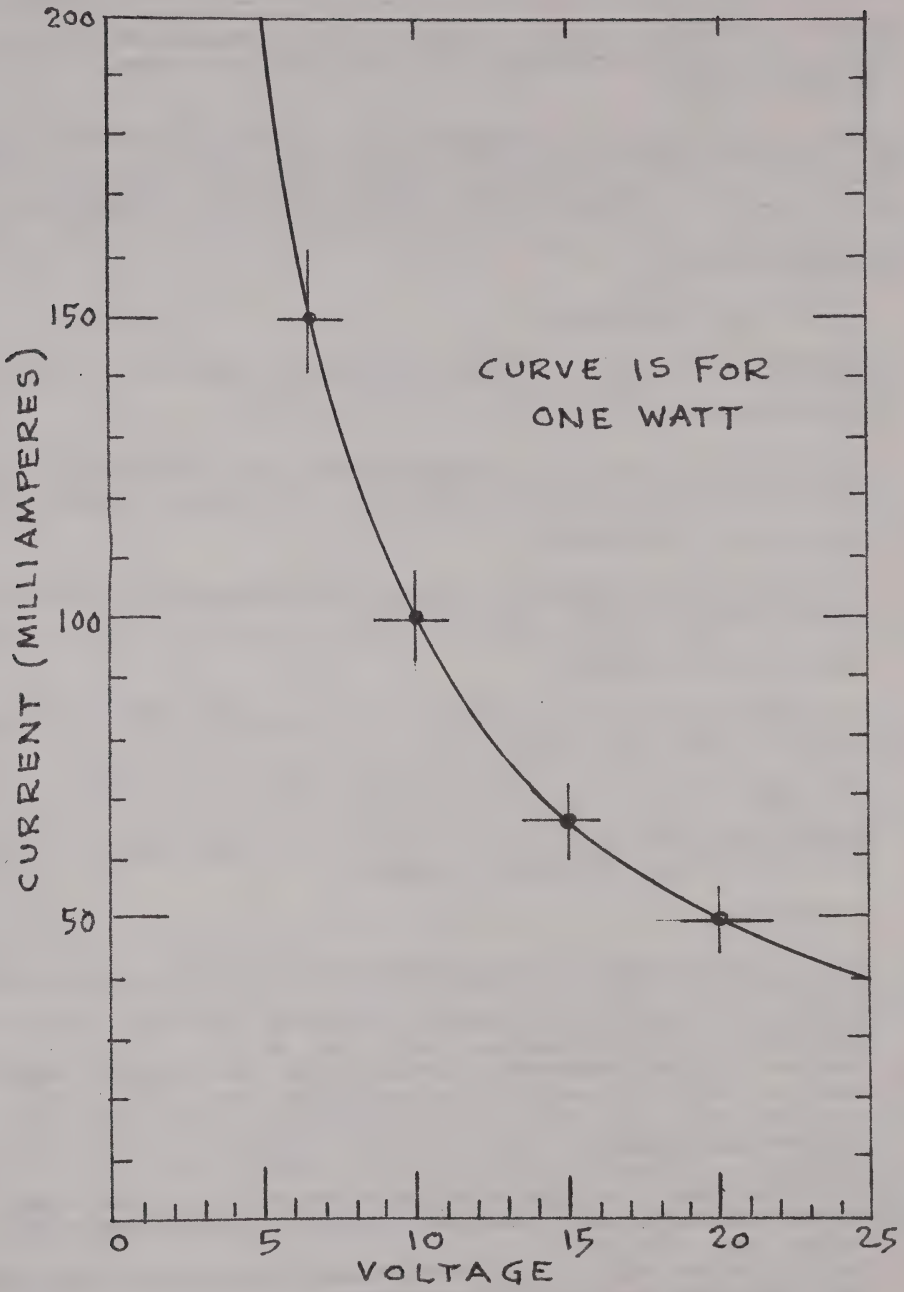

200
150
100
50
CURRENT (MILLIAMPERES)
CURVE IS FOR
ONE WATT
0
5
10
15
20
25
VOLTAGE

Fig. 4-44

APPENDIX

Reference for published articles concerning the Low Frequencies

It is very frustrating for a radio buff to recall an article in one of the many radio magazines, etc., and then go crazy, trying to find same years later.

Rodney L. Morris, South Pasadena, CA published a reference list in the March '80 issue of the LWCA publication LOWDOWN....I can fully appreciate the time it took to compile this list and want to thank Rodney for his permission to include same in this scrapbook.

Longwave Receivers

ELEMENTARY ELECTRONICS

1) Experimenters Deluxe FET-IC VLF Receiver, May-June 1975, p 49.

ELECTRONICS

1) Direction Finding at Low Frequemcies. Uses a shielded loop antenna wich tunes 15 to 500 kHz. Elaborate receiver. 9/16/60, p 74.

ELECTRONICS ILLUSTRATED

1) Low-Band Weather Receiver. Three tube regenerative receiver and a weather beacon list. July '79, p 71.

ELECTRONICS HOBBYIST

1) Sub-Basement Receiver. A FET-IC VLF receiver with loop antenna. Spring-Summer '79, p 81.

HAM RADIO

1) WWVB Signal Processor. A 60 kHz receiver with shielded loop antenna for calibrating frequency counters.

73 MAGAZINE

1) Article discusses replacing tubes in a BC-1206 receiver with transistors. June '68, p 14.
2) Weather Snooper. How to modify an AM-BCB radio for beacon reception. Includes a list of beacons. March '69, p 18.
3) Another Surplus Treasure. Conversion of the surplus R-648/ARR-41 receiver which covers 150 kHz to 25 mHz. Nov. '78, p 96.

POPULAR ELECTRONICS

1) Longwave DXer. A single tube longwave receiver. Nov. '56, p 66.
2) The VLF Receiver. One tube set covers 13 to 550 kHz with plug-in coils. Dec. '58, p 77.
3) Quality Holds Out. Letter from reader pictures and describes his 1920 Radiomarine Corp. VLF receiver.
4) An FAA Weather Receiver. Three transistor, two IC (including the ZN414) TRF receiver. Fixed tuned between 300 & 400 kHz. 6/74, p 60.

LF Reference Articles, cont'd.

QST

1) NAA Receiver. Oct. '62, p 36.
2) Flyback To The Past. One tube VLF receiver uses a TV flyback transformer for tuned corcuit. Feb. '63, p 71.
3) Still Another NAA Receiver. Mar. '63, p 53.
4) A VLF Receiver Without Tuning Capacitors Or Coils. Oct. '66, p 23.
5) A WWVL Receiver. Nov. '71, p 34 & Dec. '71, p 47.(Note:- WWVL may still be inactive).

RADIO ELECTRONICS

1) Experiment With WWVB. An elaborate 60 kHz receiver with shielded loop antenna for a self-resetting digital clock. Aug. '73, p 98.

RADIO EXPERIMENTER

1) Sub-Basement Receiver. '79 Edition, p 43 (See Electronics Hobbyist, Item 1).

RADIO & TV NEWS

1) Low Frequency Receiver. A very simple modification of BCB receiver to receive beacons.

SCIENCE & ELECTRONICS

1) All Solid State IC Low Bander. One IC, one transistor regenerative receiver tunes 80 to 420 kHz. Aug./Sept. '70, p 59.
2) Build Our One Tube Bottom Scraper. A 13 to 28 kHz Receiver. Jan. '71, p 28.

CONVERTERS

ELECTRONICS ILLUSTRATED

1) Weather Wave Converter. One transistor unit converts 250 - 350 kHz signals to 700 - 1000 kHz (BCB Band). Nov. '62, p 108.

ELECTRONICS WORLD

1) Low and Medium Frequency Converter. A three tube bandpass converter for tuning 150 to 550 kHz on a BCB receiver. Aug. '61. p 48.
2) Below the Broadcast Band. A well designed tube-type converter for 10 to 530 kHz.
3) One Tube Low Frequency Converter. Tunes 15 to 2000 kHz with output at 28 mHz.

HAM RADIO

1) Tuned VLF Converter. Inductively tuned converter covers 10 to 150 kHz without band switching. Nov. '74, p 49.

LF Reference Articles, cont'd.

2) VLF Converter. An untuned converter with 80 meter band output. July '76, p 69.
3) 200 Meters and Up. A low frequency converter by Ken Cornell, W2IMB. Nov. '76, p 24.
4) Crystal Controlled Phase-Locked receiving converter. Converter input 60 kHz to 28 mHz, output 28 to 29 mHz.

73 MAGAZINE

1) VLF-1961. A tube type longwave converter. July 61, p 29.
2) VLF Converter. Tunes 10 to 30 kHz. Schematic only. Jan. '72, p 54.
3) A Medium Frequency Converter For High Frequency Receivers. Tube type with 3.5 to 4.1 kHz output. Jan. '72, p 73.
4) Explore the World of VLF. A crystal controlled converter covering 10 to 500 kHz. Jan. '79, p 32.

POPULAR ELECTRONICS

1) Better Your Longwave DXing With A Converter. 100 to 500 kHz converter. Dec. '56, p 67.
2) 430 And Down. Two tube converter with 1500 kHz IF output. Covers 140 to 430 kHz. March '62, p 46.

QST

1) Simple Low Frequency Converter. 10 to 1600 kHz. April '64, p 17.
2) VLF Converter With Untuned Input. Feb. '65, p 27.
3) 600 to 20,000 Meters. A converter. Sept. '68, p 18.
4) A High Performance, Low Frequency Converter. June '77, p 23.
5) Longwave Converter. This one is crystal controlled. Aug. '78, p 32.

RADIO-TV EXPERIMENTER

1) Longwave Up-Verter. One transistor unit converts beacon band to 800 kHz. Oct.-Nov. '66, p 36.

WORLD RADIO

1) Extending the Tuning Range of Amateur Receivers. A 10 kHz to 15 mHz converter. Jan. '79, p 66.

CQ MAGAZINE

1) Longwave Simplified. A converter using diodes. March '76, p 41.

ANTENNAS FOR LONGWAVE USE

ELECTRONICS WORLD

1) VLF Loop Antenna. A 8' dia. shielded loop for 14 - 25 kHz. Jan. '63.

APPENDIX, cont'd.

LF Reference Articles, cont'd.

ELECTRONICS

1) Field Strength Meter Antenna. Feb. 6, 1975, p 115.

ELECTRONIC ENGINEERING

1) Components of Electrically Small Loop Antennas. A technical discussion of low frequency loop antenna design. Nov. '78, p 48, part 1. Dec. '78, p 39, part 2.

IEEE TRANSACTIONS ON ANTENNAS AND PROBAGATION

1) Radiation Efficiency of Electrically Small Loop Antennas. A technical discussion of loop antenna design. Sept. '72, p 656.
2) S/N Performance of Aperiodic Monopoles. A highly technical discussion on wide-band antennas. March '79, p 259.

HAM RADIO

1) VLF Antenna Coupler. An Active Antenna. Oct. '79, p 46.

NACHRICHTENTECH Z. (NTZ)

1) A High Performance Active Antenna Covering 10 kHz to 30 mHz. Jan. '77, p 95. (Authors note:- I have no personal knowledge of this publication).

73 MAGAZINE

1) VLF Reception. An excellent discussion of why a long wire antenna is a poor choice for VLF signal reception, by R. Burhans. May '79, p. 157.

WORLD RADIO

1) Construction of Loops. A series of articles by Chuck Clark on the theory and design of loop antennas. June-August '79 (Authors note:- This is MUST reading for loop antenna buffs).

MASTER HANDBOOK OF 1001 PRACTICAL ELECTRONIC CIRCUITS
TAB Book No. 800, 1975

1) No Title. A loop antenna and FET differential preamplifier for WWVB, 60 kHz.

The following articles describe loop antennas for amateur band use, but which have design ideas that could be adaptable for longwave use.

HAM RADIO

1) Loop Antennas. Theory and construction of shielded loop antennas. Dec. '76, p 18.

LF Reference Articles, cont'd.

QST

1) Beat The Noise With A "Scoop Loop". Describes a ferrite rod antenna and a large wire loop antenna. Describes transistor preamplifier circuits. July '71, p 30.
2) A Receiving Loop for 160 Meters. A shielded loop antenna made from coaxial cable. Mar. '74, p 38.

TUNERS AND FILTERS

CQ MAGAZINE

1) Low Pass Filter for 5 to 500 kHz receivers. Jan. '66, p 46.

POPULAR ELECTRONICS

1) Boosting Your Longwave DX. One tube preamplifier with BCB filters for 100 to 5000 kHz. Feb. '57, p 86.

QST

1) Homemade Honeycombs. How to build honeycomb coils covering 120 to 240,000 meters. Jan. '63, p 60.

OPERATION ON THE 1750 METER BAND (160 to 190 kHz)

HAM RADIO HORIZONS

1) Exploring The 1750 Meter Band. An honest evaluation of what an experimenter can expect on this nonlicensed communication band. A frank discussion and suggestions on equipment design by Ken Cornell, W2IMB. April '77, p 20.

73 MAGAZINE

1) QRP ON 180 kHz. May '73, p 93.

CQ MAGAZINE

1) 1750 Meters. A Transmitter for this band. April '68, p 31. (Authors Note:- I firmly believe that this article probably was the main "motive force" that started the LOWFERS" activities. It was unfortunate that it appeared in the "April" issue, as many readers thought that it was an "April Fool" article.).
2) QRP On 1750 Meters. An excellent article on operation on this band by Pete Bradley. Nov. '79, p 35.

S9 MAGAZINE

1) Low Band CB'ing. Operation on the 1750 meter band. Nov. 64, p 25.
2) The P-15 Low Bander Rig. Conversion of the Lafayette PA-405 wireless intercom for 1750 meter voice transmission. Nov. '64, p 27.
3) Be A Lowfer. Getting on the air. Sept. '79, p 22.

LF Reference Articles, cont'd.

4) The Runt. A low powered transmitter using the Raytheon CK526AX subminiature tube. May '70, p 16.

POPULAR ELECTRONICS

1) Transmitter For The Neglected Band (1750 meters). Jan. '72.
2) Tuner For The Neglected Band (1750 meters). Feb. '72
Authors note:- I have commented on this series of articles in my earlier scrapbook editions and suggest a review of same be made before construction is considered.

QST

1) A Crystal Controlled Converter and Simple Transmitter For 1750 Meter Operation. A station designed by Jim Hagan. Jan. '74, p 19.
2) LOWFERS. Low frequency experimenters. Misc. excerpts. Mar. '78.
3) A One Year Study Of The 1750 Meter Band. Mentions the LWCA. Aug. '79, p 42.

VLF RECEIVERS FOR DETECTION OF SOLAR FLARES

ELECTRONIC EXPERIMENTERS HANDBOOK

1) Listen In On The Sun. A transistor VLF receiver tunes in on the Sun for detection of solar flares. Spring, '67, p 73.

RADIO ELECTRONICS

1) Improved Solar Flare Indicator. A three transistor 27 kHz set for recording atmospherics. Jan. '59, p 40.

SKY AND TELESCOPE

1) Building A Recorder for Sudded Enhancement of Atmospherics. A VLF receiver for detecting solar flares. June '73, p 392.

GENERAL REVIEWS OF THE LONGAVE BAND

POPULAR ELECTRONICS

1) The Comeback Trail For Longwave DX. General discussion. Oct. '56.
2) What's On The Air Below 500 kHz, Part 1. An overall look at the low frequency range. Feb. '80. p 88.
3) Ditto, Part 2. Longwave receiving equipment and the 1750 meter band. Mar. '80, p 75.

RADIO-TV EXPERIMENTER

1) A Guide To VLF Listening. Explains VLF to DX'rs. Includes a list of stations. April-May '76. p 50.

LF Reference Articles, cont'd.

LIGHTNING AND WHISTLERS

ELECTRONICS EXPERIMENTERS HANDBOOK

1) The Cloud Sentinel. A monitor for lightning discharges. Spring '65.

POPULAR ELECTRONICS

1) Thunderbolts and Whistlers. How to hear whistlers. Dec. '59, p 39.
2) Build The Black Box That Hears Missles. A four foot box loop and transistor preamplifier for 4 to 16 kHz. April '59, p 102.

QST

1) Amateur VLF Observation. How to listen for whistlers. Mar. '60.

SPECTRUM - BRITISH SCIENCE NEWS

1) Tell-Tale Whistlers From Space. VLF radio pulses from lightning and how they are used to study the magnetosphere. No. 157, '78.

A MODERN TRANSISTOR WORKBOOK (Radio Shack)

1) VLF Whistler Receiver. A loop antenna with a premplifier that covers 4 to 16 kHz. 1965, p 43.

ELF AND PROJECT SANGUINE-SEAFARER

PROCEEDINGS IEEE

1) Biological Effects Of Electric and Magnetic Fields Associated With ELF Communication Systems. No. 68, Jan. '80, p 98.

IEEE TRANSACTIONS ON GEOSCIENCE ELECTRONICS

1) An ELF Wide-Band Noise Receiver. A receiver-recorder for study of ELF atmospherics. April '72, p 113.

SATURDAY REVIEW

1) The Invisible Threat. The stifled story of electric waves. Discusses ELF radiation from power lines and Project Sanguine-Seafarer. Sept. 15 '79, p 16.

73 MAGAZINE

1) Extremely Low Frequency Radiation. Cause for worry? Possible biological hazards from ELF power line radiation. Oct. '79, p 35.

APPENDIX, cont'd.

LF Reference Articles, cont'd.

MISC. LONGWAVE TOPICS

ELECTRONICS

1) Navy Transmitter Will Radiate 100 KW. Description of station NLK. Dec. '52, p 98.
2) Calibrating Frequency Standards With VLF Transmissions. Not a construction article. April 27 '71, p 60.
3) Air Force Seeks To Block Noise. An aircraft communication system operating from 17 to 60 kHz with 200 KW power using an antenna wire 8000 feet long, with a 26,700 foot trailing ground wire. Spread spectrum modulation techniques will be used. An electronic interference canceller using electronic cancellation of the noise pulses. May 24 '79, p 94.

ELECTRONICS WORLD

1) Naval Observatory Time Signals. Describes time signals including VLF. Aug. '63, p 30.

ELECTRONICS ILLUSTRATED

1) The Forgotten World Of Longwave Broadcasting. A DX'rs guide to LF BC listening. Nov. '67, p 96.

CQ MAGAZINE

1) Weather and Press Transmissions for Code Practice and Probagation Checking. Includes some longwave station listings that are out of date. April '69, p 79.

HAM RADIO

1) VLF Dip Meter Converter. This adapter allows your dip meter to be used as low as 1 kHz. Aug. '79, p 26.

QST

1) Description of VLF 2 Megawatt Station NAA. Oct. '61, p 80.
2) Down To The Sea In Ships. Listening in on the 405 to 535 kHz marine band. April '70, p 58.

Too conclude this reference list of interesting published articles involved with the low frequency range, the author takes no responsibility on the accuracy of same or the completeness therein.

It is only presented as a reference to interested experimenters and radio buffs, that may wish to review some old and interesting articles.

For up-to-date information regarding the low frequencies, the monthly publication of the Longwave Club of America, called the LOWDOWN is your answer.....See mention of same in my introduction.

DATA CONCERNING FCC MATTERS

An item of importance is the use of "call signs" (station ID) used on the non-licensed communication bands.

Any call sign can be used as long as it is not a duplicate of a FCC licensed station....Amateur Radio call signs should not be used or you may receive a citation for "out of band operation" if a FCC monitor picks you up.

Log keeping is not required, however it would appear practical to keep a notebook on your operations listing call sign used, frequency and hours of operation, plus notes concerning the transmitter and antenna set-up....Who knows, but you may establish a DX record and the log will help identification.

Many LOWFERS also keep a record of band conditions, particularly Solar activity periods.

In most areas of the country, there are beacons or stations close to the 160 to 190 kHz band that can be monitored for an indication of band conditions....Here in the North-East, I use "TUK" that is located on Nantucket Island @ 194 kHz....They transmit voice weather reports with a tone modulated "TUK" (code) in the background.

Most every monthly edition of the LOWDOWN (see page 6) contains loggings of station reception by members scattered around the country and quite often they list LOWFERS beacons and up-dating for the Beacon Guide.

***

FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D.C. 20554

March 27, 1979

IN REPLY REFER TO:

6310/EQU/4-2-4

Mr. Ken Cornell
225 Baltimore Ave.
Point Pleasant Beach, NJ 08742

Dear Mr. Cornell:

I regret the delay in replying to your letter of January 26, 1979, concerning §15.111 of the FCC Rules. This section specifies the maximum field strength that may be radiated by a device operating in the frequency range below 1600 kHz under Part 15.

Under the formula set out in §15.111, a device operating at 175 kHz may radiate a field not to exceed 2400/175 = 13.7 μV/m at a distance of 300 meters from the source. The field strength is measured with a standard field strength meter using a calibrated antenna. At 175 kHz, a calibrated shielded loop antenna is normally used. The calibration of the antenna takes into account its physical dimensions.

The construction and calibration of a field strength meter is described in the technical literature and is seldom practical for a home experimenter. A manufacturer producing a Part 15 device for sale is expected to use a standard field strength meter to measure the radiated signal from his device. For the experimenter making and testing a device for his own use, a less precise measurement procedure may be used. The experimenter may measure the field strength by substitution. For this purpose, any good receiver with a meter in its output can be used. Observe the reading obtained with this receiver from the device being tested. Replace the device under test with a calibrated signal gererator using a standard antenna and adjust the output of the signal generator to give the same reading on the measuring receiver. The field is then calculated from the output of the signal generator and the physical dimensions of the radiated antenna.

If you are interested in pursuing the matter of field strength measurements, you will find this subject discussed in I.T.T.'s "Reference Data for Radio Engineers" published by Howard W. Sams & Co., Inc. This subject is also discussed in a series of articles in radio amateur's magazine "QST".

Sincerely,

Herman Garlan

Herman Garlan, Chief
RF Devices & Experimental Branch

FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D.C. 20554

June 8, 1981

IN REPLY REFER TO:
31030/EQU/4-2-1

Longwave Club of America
225 Baltimore Avenue
Point Pleasant Beach, NJ 08742

Attention: Ken Cornell

Dear Mr. Cornell:

Your letter of January 25, 1981 concerning RF interference at low frequencies has been forwarded to this office for response.

Control of RF interference is an ongoing concern of the Commission. Much has been done already, and we continue to look into this problem.

In November 1978, the Commission issued a Notice of Inquiry in Docket 78-369, asking for public comment on a wide variety of issues concerning radio frequency (RF) interference. A copy is enclosed for your information, and I am forwarding a copy of your letter on to the FCC personnel involved with that proceeding. A follow up action in Docket 78-369 is expected later this year.

One mechanism used by the Commission to control interference from RF equipments is the FCC equipment authorization program. Certain equipments must meet FCC limits on undesired emissions, and be approved by the Commission as a precondition to legal importation and marketing.

A copy of the FCC report, Study of the Interference Potentialities of Silicon-Controlled-Rectifiers, project 6214-2, is enclosed as you requested. SCRs, as they are called, are one of many types of electrical devices which generate radio energy as a by-product of their operation. These are classified Incidental Radiation Devices, examples of which include electric motors, fluorescent lights, and automobile ignition systems. Such devices are subject only to the general proscription against causing harmful interference. See Sections 15.25 and 15.4(b) of the enclosed extract from Part 15. The kind of interference you describe does not appear to be harmful interference as defined in Section 15.4(b).

The Commission's Field Office Bureau, which has offices throughout the country deals with individual cases of interference. The Field Operations Bureau has published a booklet "How to Identify and Resolve Radio-TV Interference Problems" which I believe you will find informative.

I trust that this information will be of assistance to you. I apologize for the delay of this reply.

Sincerely,

Art Wall
Chief,
RF Devices Branch

Enclosures:
Interference Handbook
Subpart A, Part 15
FCC Lab Report 6214-2, April 1, 1966
NPRM, Docket 20780

Subpart D—Low Power Communication Devices: General Requirements

§ 15.101 Introduction.

A low power communication device may be operated pursuant to the provisions in this subpart or pursuant to the separate provisions for the specific device in Subpart E of this part.

§ 15.102 Cross reference.

The provisions of Subparts A and B of this Part and Subpart J of Part 2 of this chapter shall apply to the operation of all low power communication devices.

§ 15.103 Interference.

Notwithstanding the other requirements of this part, the operator of a low power communication device, regardless of date of manufacture, which causes harmful interference to an authorized radio service, shall promptly stop operating the device until the harmful interference has been limited.

§ 15.104 Eavesdropping prohibited.

As provided in § 15.11, the use of a low power communication device for eavesdropping is prohibited.

§ 15.105 Class B emission prohibited.

Operation of a low power communication device that produces Class B emissions (damped waves) is prohibited.

§§ 15.106–15.110 [Reserved]

§ 15.111 Operation below 1600 kHz.

A low power communication device may be operated on any frequency between 10 and 490 kHz or between 510 and 1600 kHz subject to the condition that the emission of RF energy on the fundamental frequency or any harmonic or other spurious frequency does not exceed the field strength in the following table.

Frequency (kilohertz)	Distance (meters)	Field strength (microvolts per meter)
10 to 490	300	$\frac{2,400}{F(kHz)}$
510 to 1600	30	$\frac{24,000}{F(kHz)}$

§ 15.112 Alternative provisions for operation between 160 and 190 kHz.

In lieu of meeting the requirements of § 15.111, a low power communication device may operate on any frequency in the band 160–190 kHz provided it meets all the following conditions:

(a) The power input to the final radio frequency stage (exclusive of filament or heater power) does not exceed one watt.

(b) All emissions below 160 kHz or above 190 kHz are suppressed 20 dB below the unmodulated carrier.

(c) The total length of the transmission line plus the antenna does not exceed 15 meters.

§ 15.113 Alternative provisions for operation between 510 and 1600 kHz.

In lieu of meeting the requirements of § 15.111, a low power communication device may operate on any frequency in the band 510–1600 kHz provided it meets all the following conditions.

(a) The power input to the final radio stage (exclusive of filament or heater power) does not exceed 100 milliwatts.

(b) The emissions below 510 kHz or above 1600 kHz are suppressed 20 dB or more below the unmodulated carrier.

(c) The total length of the transmission line plus the antenna, plus the ground lead (if used) does not exceed 3 meters.

(d) Low power communication devices obtaining their power from the lines of public utility systems shall limit the radio frequency voltage appearing on each power line to 200 microvolts or less on any frequency from 510 kHz to 1600 kHz. Measurements shall be made from each power line to ground both with the equipment grounded and with the equipment ungrounded.

§ 15.114 [Reserved]

§ 15.115 Interim requirements for operation between 26.97 and 27.27 MHz.

A low power communications device complying with all the provisions of paragraphs (a) through (d) of this section, may be operated until March 18, 1983. Manufacture and marketing of such a device shall cease March 18, 1977 and March 18, 1978, respectively. Operation of such a device shall be terminated not later than March 18, 1983.

(a) The carrier of the device shall be maintained within the band 26.97–27.27 MHz.

(b) All emissions, including modulation products, below 26.97 MHz or above 27.27 MHz shall be suppressed 20 dB or more below the level of the unmodulated carrier.

(c) The DC power input to the final radio stage (exclusive of filament or heater power) shall not exceed 100 milliwatts.

(d) The antenna shall consist of a single element that does not exceed 1.5m (=5 feet) in length.

§ 15.116 Operation of a non-voice device between 26.99–27.26 MHz.

A low power communication device may be operated in the band 26.99–27.26 MHz provided it meets all of the following requirements:

(a) The device may *not* be used for voice communications (F3 or A3), or for CW communications (A1).

(b) The device shall operate on one or more of the following frequencies:

26.995 MHz	27.145 MHz
27.045 MHz	27.195 MHz
27.095 MHz	27.255 MHz

(c) Frequency tolerance of carrier: ±0.01%. This tolerance shall be maintained for a temperature variation of −20° to +50° C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20° C.

(d) Emission shall be confined within a 20 kHz band centered on the carrier frequency.

(e) The emission of RF energy on the carrier frequency shall not exceed 10,000 μV/m measured at 3 meters.

(f) The out-of-band emissions, including harmonics, on any frequency more than 10 kHz removed from the carrier shall not exceed 500 μV/m measured at 3 meters. The spectrum shall be scanned from 10 to 1000 MHz and all signals exceeding 50 μV/m at 3 meters shall be reported.

(g) If the device is designed to operate from public utility lines, the RF energy fed back into the power lines shall not exceed 100 microvolts on any frequency below 25 MHz.

§ 15.117 Operation between 49.82–49.90 MHz.

A low power communication device may be operated on one or more of the permitted frequencies listed in this section without any restriction on the type of modulation provided it complies with all the technical specifications of § 15.118 or § 15.119.

Permitted frequencies of operation:

49.830 MHz	49.875 MHz
49.845 MHz	49.890 MHz
49.860 MHz	

§ 15.118 Technical specification for the band 49.82–49.90 MHz.

A low power communication device that is marketed or that is home built in a quantity greater than 5 and is not marketed, must meet all the technical specifications in this section.

(a) Frequency tolerance of carrier: ±0.01%. This tolerance shall be maintained for a temperature variation of −20° to +50° C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20° C.

(b) Emission shall be confined within a 20 kHz band centered on the carrier frequency.

(c) The emission of RF energy on the carrier frequency shall not exceed 10,000 μV/m measured at 3 meters.

(d) The out-of-band emissions, including harmonics, on any frequency more than 10 kHz removed from the carrier shall not exceed 500 μV/m measured at 3 meters. The spectrum shall be scanned from 25 to 1000 MHz and all signals exceeding 50 μV/m at 3 meters shall be reported.

(e) The device shall be completely self-contained with the antenna permanently attached to the box containing the device. If a microphone is used it shall be built into the enclosure. No remote operating position is permitted (only remote telemetry of data is permitted).

(f) If the device is designed to operate from public utility lines, the RF energy fed back into the power lines shall not exceed 100 microvolts on any frequency below 25 MHz.

§ 15.119 Alternative technical specifications for the band 49.82–49.90 MHz.

A low power communication device which is home built in a quantity of 5 or less and which is not marketed may be operated in the band 49.82–49.90 MHz provided it meets all the following technical specifications.

(a) The RF carrier and modulation products shall be maintained within the band 49.82–49.90 MHz.

(b) The power input to the device measured at the battery or the power line terminals shall not exceed 100 milliwatts under any condition of modulation.

(c) The antenna shall be a single element 1 meter or less in length permanently mounted on the enclosure containing the device.

(d) The device shall be completely self-contained with the antenna permanently attached to the enclosure containing the device. If a microphone is used it shall be built into the enclosure. No remote operating position is permitted (only remote telemetry of data is permitted).

(e) Harmonic emissions shall be suppressed at least 20 dB below the level of the unmodulated carrier.

§ 15.120 Operation above 70 MHz.

A low power communication device may be operated on any frequency above 70 MHz, subject to the following conditions:

(a) The emission of RF energy on the fundamental frequency or any harmonic or other spurious frequency shall not exceed the field strength in the following table:

Frequency (MHz):	*Field strength (μV/m at 30 m)*
70 to 130	50.
130 to 174	50 to 150 (linear interpolation).
174 to 260	150.
260 to 470	150 to 500 (linear interpolation).
470 and above	500.

(b) The device is provided with means for automatically limiting operation so that the duration of each transmission shall not be greater than 1 second and the silent period between transmissions shall not be less than 30 seconds.

(c) The device shall be so constructed that there are no external or readily accessible controls which may be adjusted to permit operation in a manner inconsistent with the provisions of this section.

§§ 15.121–15.130 [Reserved]

§ 15.131 Certification required for devices that are marketed or built in a quantity greater than 5 and not marketed.

(a) A low power communication device manufactured between December 31, 1957 and October 1, 1975 which is marketed or which is built in a quantity greater than 5 and not marketed, shall be self-certificated pursuant to the provisions of §§ 15.135–15.136.

(b) A low power communication device manufactured after October 1, 1975 which is marketed or built in a quantity greater than 5 and not marketed shall be certificated pursuant to Subpart B of this part.

§ 15.132 Identification required for devices that are marketed or built in a quantity greater than 5 and not marketed.

A low power communication device manufactured after October 1, 1975 which is marketed shall be identified pursuant to Subpart B of this part. Each device shall bear an identification label containing information shown in the sample label below.

FCC IDENTIFICATION DATA

(Name)

Model No.: ---

(Identifier)

This device complies with FCC Rules Part 15 as of date of manufacture.

(Date of manufacture)

(a) *Name.* This shall include the trade name, if any, and the name and address of the manufacturer or of the vendor provided the name of the latter was included in the application for certification.

(b) *Identifier.* This is the model number assigned to the device by the manufacturer or applicant for certification and must be identical to that shown on the application for certification. This identifier must be preceded by the words "MODEL NO.".

(c) *Date.* This is the month and year when the device was manufactured. If desired, this may be coded, provided the code therefor is filed with the application for certification.

(d) For applications filed prior to April 1, 1976, the Commission will accept alternative methods of identification provided the name pursuant to paragraph (a) of this section, the number pursuant to paragraph (b) of this section and the date pursuant to paragraph (c) of this section are clearly identifiable, separate and distinct from any other name or number or designator on the equipment.

§ 15.133 Certification and identification required for home built device.

A person who constructs not more than five low power communication devices for his own use, and not for sale, need not meet the requirements of § 15.131 and § 15.132. In lieu thereof, he shall attach to each such device a signed and dated label that reads as follows:

I have constructed this device for my own use. I have tested it and certify that it complies with the applicable regulations of FCC Rules Part 15. A copy of my measurements is in my possession and is available for inspection.

(Signature) (Date)

§ 15.134 [Reserved]

§ 15.135 Certification procedure: Device manufactured between December 31, 1957 and October 1, 1975.

A low power communication device manufactured between December 31, 1957 and October 1, 1975 shall be self-certificated as follows:

(a) The owner or operator need not certificate his own low power communication device, if it has been certificated by the manufacturer or distributor.

(b) Where certification is based on measurement of a prototype, a sufficient number of units shall be tested to assure that all production units comply with the technical requirements of this subpart.

(c) The certificate may be executed by a technician skilled in making and interpreting the measurements that are required to assure compliance with the requirements of this part.

(d) The certificate shall contain the following information:

(1) The operating conditions under which the device is intended to be used.

(2) The antenna to be used with the device.

(3) A statement certifying that the device can be expected to comply with the requirements of this subpart under the operating conditions specified in the certificate.

(4) The month and year in which the device was manufactured.

§ 15.136 Location of certificate on devices manufactured between December 31, 1957 and October 1, 1975.

The certificate shall be permanently attached to the device and shall be readily visible for inspection.

§§ 15.137–15.140 [Reserved]

§ 15.141 Measurement procedure.

(a) Any procedure acceptable to the Commission may be used to measure the RF energy emitted by a lower power communication device.

(b) The procedure used at the FCC Laboratory for type approval testing of a wireless microphone operating in the band 88–108 MHz is given in FCC Bulletin OCE 19 available from the Commission.

(c) The procedure for measuring the radiation of RF energy from the transmitter and receiver parts of a radio control for a door opener is set out in FCC

Technical Report T-7001 available from the Commission.

§15.142 Range of measurements.

Measurements of radiated energy from a low power communications device shall be made over the frequency range listed below.

Frequency band in which the device operates	Range of frequency measurements	
	Lowest frequency	Highest frequency
Below 1600 kHz	10 kHz	20 MHz.
26.97 to 27.27 MHz	Lowest frequency generated in the device.	400 MHz.
49.82 to 49.90 MHz	Lowest frequency generated in the device or 25 MHz, whichever is lower.	1000 MHz.
70 to 108 MHz	do	1000 MHz.
108 to 500 MHz	do	2000 MHz.
500 to 1000 MHz	Lowest frequency generated in the device or 100 MHz whichever is lower.	5000 MHz.

§ 15.143 Report of measurements.

The report of measurements for a low power communication device operating under the provisions of this subpart manufactured after October 1, 1975 shall include the following:

(a) Specific identification of the device that was measured including name and address of manufacturer, the name of the applicant for certification, if different, the trade name if any, the model number, and serial number, if any.

(b) A detailed description of the measurement procedure that was used. If a published standard was used, reference to the standard is sufficient. If the standard was not followed in every detail, describe how the actual procedure used differed from that in the standard.

(c) Date the measurements were made.

(d) Location where the measurements were made.

NOTE.—A description of this measurement facility must be filed under § 15.38.

(e) Measurements shall be reported separately for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following schedule.

Frequency range over which device operates	Number of frequencies	Location in the range of operation
1 MHz	1	Middle.
1 to 10 MHz	2	One near top. One near bottom.
Over 10 MHz	3	One near top. One near middle. One near bottom.

(f) Measurements of radiated RF energy shall be reported in the following format:

Frequency to which tuned (megahertz)	Frequency of the emission (megahertz)	Distance at which measured	Meter reading (Note 1)	Note 2	Note 2	Field strength microvolts per meter at—meters (Note 3)

NOTE 1.—Specify units (microvolts per meter, dB, etc.)
NOTE 2.—Indicate the constants or factors used to convert the meter reading to field strength at the distance specified in the rules. Indicate the units for each constant.
NOTE 3.—Specify the distance in meters.

(g) Mean RF power output of the device.

(h) Input power measured at the battery terminals if battery powered or at power supply terminals if AC/DC line operated.

(i) If the applicable regulation limits the power input, submit measurements showing the variation of the power input with variation of battery or supply voltage between 85 and 115 percent of the nominal rated supply voltage.

(j) If the applicable regulation limits the level of radiated signal, submit measurements of radiation over the frequency range specified in § 15.142. In addition, submit measurements to show the variation of radiation level on the fundamental with variation of supply voltage between 85 and 115 percent of the nominal rated supply voltage.

(k) The report shall be personally signed by the engineer taking responsibility for the accuracy of the measurements who shall certify to the accuracy of the measurements. If an employee of the applicant, the report shall so state. If employed by an engineering firm or laboratory, the report shall indicate the name and address of such firm. If self-employed, the report shall include the address of the engineer.

Subpart E—Low Power Communication Devices: Specific Devices

§ 15.151 Cross reference.

The provisions of Subparts A and B of this part and Subpart J of Part 2 of this chapter shall apply to a low power communication device operating under this subpart.

§ 15.152 Interference from a low power communication device.

Notwithstanding the other requirements of this part, the operator of a low power communication device, regardless of date of manufacture, which causes harmful interference to an authorized radio service, shall promptly stop operating the device until the harmful interference has been eliminated.

§ 15.153 Class B emission prohibited.

Operation of a low power communication device that produces Class B emissions (damped waves) is prohibited.

§ 15.154 Eavesdropping prohibited.

As provided by § 15.11 the use of a low power communication device for eavesdropping is prohibited.

WIRELESS MICROPHONE

§ 15.161 General technical provisions.

A wireless microphone may operate in any of the frequency bands listed under Subpart D of this part pursuant to the provisions therein.

§ 15.162 Operation in the band 88–108 MHz.

A wireless microphone may operate on any frequency in the band 88–108 MHz provided it meets all the following conditions.

(a) Emissions from the device shall be confined within a band 200 kHz wide centered on the operating frequency. The 200 kHz band shall lie wholly within the frequency range 88–108 MHz.

(b) The field strength of emissions radiated within the specified 200 kHz band shall not exceed 50 μV/m at a distance of 15 meters from the device.

(c) The field strength of emissions radiated on any frequency outside the specified 200 kHz band shall not exceed 40 μV/m at a distance of 3 meters from the device.

(d) No antenna other than that furnished by the manufacturer shall be used with a type approved wireless microphone.

(e) A type approved wireless microphone may not be used for two way communication.

NOTE.—This regulation prohibits the use of a wireless microphone either for the exchange of communications between devices each operating in the band 88–108 MHz, or between devices one of which operates in the band 88–108 MHz.

(f) User of the device shall take adequate precautions to insure that harmful interference is not caused to the reception of transmissions from any FM or television broadcast station or any other class of station licensed by the Commission. In the event that such interference does occur, operation of the wireless microphone shall be promptly suspended and shall not be resumed until the interference has been eliminated. The user of this device must accept any interference which may be caused by the operation of any licensed station operating in accordance with the terms of its license.

§ 15.163 Equipment authorization required.

(a) A wireless microphone operating in the band 88–108 MHz shall be type approved pursuant to Subpart B of this part.

NOTE.—The receiver used with the wireless microphone must be certificated pursuant to Subpart B to show compliance with Subpart C of this part.

(b) A wireless microphone manufactured on or after October 1, 1975, operating on any of the frequencies and under the technical specifications in Subpart D of this part, shall be certificated pursuant to Subpart B of this part.

(c) A wireless microphone manufactured between December 31, 1957, and October 1, 1975, operating on any of the frequencies and under the technical specification in Subpart D of this part, shall be self-certificated pursuant to the provisions of §§ 15.135 and 15.136.

§ 15.164 Identification.

A wireless microphone shall be identified pursuant to provisions of Subpart B of this part.

TELEMETERING DEVICE

§ 15.171 General technical provisions.

A telemetering device may operate in any of the frequency bands listed under Subpart D of this part, pursuant to the provisions therein.

§ 15.172 Operation in the band 38–41 MHz.

A telemetering device may operate in the band 38–41 MHz provided it meets all the following conditions.

(a) The device is used only for the transmission of biomedical data.

(b) Emissions from the device are confined within a 200 kHz band which shall lie wholly within the frequency range 38–41 MHz.

(c) The field strength of emissions radiated within the specified 200 kHz band shall not exceed 10 μV/m at 15 meters from the device.

(d) The field strength of emissions radiated on any frequency outside the specified 200 kHz band shall not exceed 10 μV/m at 3 meters from the device.

§ 15.173 [Reserved]

§ 15.174 Operation in the band 88–108 MHz.

A telemetering device may operate on any frequency in the band 88–108 MHz provided it meets all the following conditions.

(a) Emissions from the device shall be confined within a band 200 kHz wide centered on the operating frequency. The 200 kHz band shall lie wholly within the frequency range 88–108 MHz.

NOTE.—To insure that this requirement is met, the carrier frequency must be maintained within the band 88.1–107.9 MHz.

(b) The field strength of emissions radiated within the specified 200 kHz band shall not exceed 50 μV/m at 15 meters from the device.

(c) The field strength of emissions radiated on any frequency outside the specified 200 kHz band shall not exceed 40 μV/m at 3 meters from the device.

(d) No antenna other than that furnished by the manufacturer shall be used with a type approved telemetering device.

(e) The device shall not be used for two way communication.

(f) User of the device shall take adequate precautions to insure that harmful interference is not caused to the reception of transmissions from any FM or television broadcast station or any other class of station licensed by the Commission. In the event that such interference does occur, operation of the telemetering device shall be promptly suspended and shall not be resumed until the interference has been eliminated. The user of the device must accept any interference which may be caused by the operation of any licensed station operating in accordance with the terms of its license.

§ 15.175 Custom built telemetering device in the band 88–108 MHz.

A custom built telemetering device used for experimentation by an educational institution need not be type approved, *Provided:*

(a) The device complies with the technical requirements of § 15.172 (a) through (c) inclusive.

(b) The educational institution notifies the Engineer in Charge of the local FCC office, in writing, in advance of operation. The notice shall include:

(1) The dates and place where the device will be operated.

(2) The purpose for which the device will be used.

(3) A description of the device including the operating frequency, RF power output, and antenna.

(4) A statement that the device complies with the technical provisions of § 15.172 (a) through (c) inclusive.

§ 15.176 Operation in the band 174–216 MHz.

A telemetering device may operate in the band 174–216 MHz provided it meets all the following conditions.

(a) The device is used only for the transmission of biomedical data.

(b) Emissions from the device are confined within a 200 kHz band which shall lie wholly within the frequency range 174–216 MHz.

(c) The field strength of emissions radiated within the specified 200 kHz band shall not exceed 150 μV/m at 30 meters from the device.

(d) The field strength of emissions radiated on any frequency outside the specified 200 kHz band shall not exceed 15 μV/m at 30 meters from the device.

§ 15.177 Equipment authorization required.

(a) A telemetering device operating in the band 88–108 MHz, other than a custom built device operating under § 15.174, shall be type approved pursuant to Subpart B of this part.

(b) A custom built telemetering device operating under § 15.175 shall file the notice prescribed therein with the Engineer in Charge of the local FCC office.

(c) A biomedical telemetering device operating in the bands 38–41 or 174–216 MHz that was manufactured after April 30, 1972 shall be certificated pursuant to Subpart B of this part.

(d) The receiver associated with a radio telemetering device must be separately certificated pursuant to Subpart B to show compliance with Subpart C of this part.

§ 15.178 Identification.

(a) A telemetering device shall be identified pursuant to the provisions of Subpart B of this part.

(b) A biomedical telemetering device operating under § 15.172 or § 15.176 shall bear a label containing the following information.

(1) Name pursuant to § 2.1045(a) of this chapter.

(2) Model number pursuant to § 2.1045(b) of this chapter.

(3) The following statement: This device complies with FCC Part 15. Operation is subject to the following two conditions: (1) This device may not cause harmful interference and (2) this device must accept any interference that may be received, including interference that may cause undesired operation.

(4) The date of manufacture: This information may be inscribed as the month and year of manufacture, or coded at the manufacturer's option, provided the key to the code is submitted with the application for certifiction.

§ 15.179 Report of measurements.

The report of measurements for a biomedical telemetering device operating under § 15.172 or § 15.176 shall report measurements pursuant to § 15.143.

RADIO CONTROL FOR DOOR OPENER (GARAGE DOOR OPENER DEVICE)

§ 15.181 General technical provisions.

A radio control for a door opener may operate in any of the frequency bands listed under Subpart D of this part, pursuant to the provisions therein.

§ 15.182 Operation above 70 MHz: Devices manufactured prior to July 15, 1963.

A radio control for a door opener manufactured prior to July 15, 1963 may be operated on any frequency above 70 MHz provided it meets all of the following conditions:

(a) The emission of RF energy shall not exceed the following limits:

Frequency (MHz):	*Field strength (μV/m at 30 meters)*
70 to 130	50.
130 to 174	50 to 150 (linear interpolation).
174 to 260	150.
260 to 470	150 to 500 (linear interpolation).
Above 470	500.

(b) The device is provided with means for automatically limiting operation to a duration of not more than 1 second, not to occur more than once in 30 seconds.

§ 15.183 Operation above 70 MHz: Devices manufactured between July 15, 1963 and March 24, 1971.

A radio control for a door opener manufactured between July 15, 1963 and March 24, 1971 may be operated on any frequency above 70 MHz provided it meets all of the following conditions:

(a) The emission of RF energy shall not exceed the following limits:

Frequency (MHz):	*Field strength (μV/m at 30 meters)*
70 to 130	50.
130 to 174	50 to 150 (linear interpolation).
174 to 260	150.
260 to 470	150 to 500 (linear interpolation).
Above 470	500.

(b) Radiation from the transmitter or receiver part of the control must not fall within any of the following bands:

MHz	*MHz*
73 to 75.4	1535 to 1670
108 to 118	2690 to 2700
121.4 to 121.6	4200 to 4400
242.8 to 243.2	4990 to 5250
265 to 285	*GHz*
328.6 to 335.4	10.68 to 10.70
406 to 410	15.35 to 15.4
608 to 614	19.3 to 19.4
960 to 1215	31.3 to 31.5
1400 to 1427	88 to 90

NOTE.—A radiation level below 15 μV/m at 1 meter will be considered to meet this requirement.

(c) The transmitter part of the control is activated by a switch which automatically turns the transmitter off when released. If not so activated, the control shall meet the duty cycle limitation in § 15.120(b).

(d) The device shall be so constructed that there are no external or readily accessible controls which may be adjusted to permit operation in a manner inconsistent with the provisions of this section.

§ 15.184 Operation above 70 MHz: Devices manufactured after March 24, 1971.

A radio control for a door opener manufactured after March 24, 1971 may operate on any frequency above 70 MHz provided it meets all the following conditions:

(a) The device may be used only for the purposes of opening or closing a door and may not be used for voice transmission or the transmission of any other type of message or information.

(b) Emission of RF energy from the transmitter, as well as from the receiver part of the control, shall not fall within any of the bands listed below:

MHz	*MHz*
73 to 75.4	608 to 614
108 to 118	960 to 1215
121.4 to 121.6	1400 to 1427
242.8 to 243.2	1535 to 1670
265 to 285	2690 to 2700
328.6 to 335.4	4200 to 4400
404 to 406	4990 to 5250
	GHz
	10.68 to 10.70
	15.35 to 15.4
	19.3 to 19.4
	31.3 to 31.5
	88 to 90

NOTE.—A radiation level below 15 μV/m at 1 meter will be considered to meet this requirement.

(c) Subject to the limitation in paragraph (b) of this section, emission of RF energy from the transmitter shall not exceed the levels given below when measured under open field conditions as prescribed in FCC Technical Division Report T–7001 dated October 1, 1970 available from the Commission.

Frequency (MHz):	*Field strength at 30 meters (μV/m)*
70 to 130	125 to 375 (linear interpolation).
130 to 174	125.
174 to 260	375.
260 to 470	375 to 1250 (linear interpolation).
Above 470	1250.

(d) The transmitter part of the control shall be activated only by a switch which will automatically deactivate the transmitter when released. The switch shall be of such quality to insure reliable operation for the expected life of the transmitter.

§ 15.185 Equipment authorization required.

(a) A radio control for a door opener operating above 70 MHz manufactured after March 24, 1971 shall be certificated pursuant to Subpart B of this part.

(b) A radio control for a door opener operating above 70 MHz under §§ 15.182 or 15.183 shall be self-certificated pursuant to §§ 15.135 and 15.136.

(c) The receiver associated with a radio control transmitter for a door opener shall be certificated pursuant to Subpart B to show compliance with Subpart C of this part.

§ 15.186 Identification.

(a) A radio control device for a door opener shall be identified pursuant to the provisions of Subpart B of this part.

(b) The transmitter part and the receiver part of the radio control for a door opener operating under § 15.184 shall each bear a label containing the following information:

(1) Name pursuant to § 2.1045(a) of this chapter.

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(2) Model number pursuant to § 2.1045(b) of this chapter.

(3) The following statement: This device complies with FCC Rules Part 15. Operation of this device is subject to the following two conditions: (1) This device may not cause harmful interference. (2) This device must accept any interference that may be received including interference that may cause undesired operation.

§ 15.187 Report of measurements.

The report of measurements for a radio control for a door opener operating under § 15.184 shall cover the range of frequencies in § 15.142 of this part and shall contain the information required by § 15.143.

Device That Measures the Characteristics of a Material

§ 15.191 General technical provisions.

A device that uses RF energy to measure the characteristics of a material may operate in any of the frequency bands listed under Subpart D of this part pursuant to the provisions therein.

§ 15.192 Alternative provisions.

A device that uses RF energy to measure the characteristics of a material may operate in the frequency bands listed in paragraph (b) and pursuant to the provisions in this section.

(a) A device operated pursuant to the provisions of this section may not be used for voice communications, or the transmission of any other type of message.

(b) The device shall operate within the frequency bands:

MHz	*MHz*
13.554 to 13.566	2400 to 2500
26.96 to 27.28	5725 to 5875
40.66 to 40.70	24000 to 24250
890 to 940 (see note)	

Note.—The frequency band 890–940 MHz is subject to change pursuant to the reallocation of frequencies that may be made in the band 806–960 MHz in the rule making proceeding in Docket No. 18262.

(c) The maximum level of emission from the device shall not exceed:

Fundamental frequency in the band	Emission (microvolts per meter at 30 meters)		
	On fundamental frequency	On harmonic frequencies	On other frequencies
13.554 to 13.566	15	0.5	0.5
26.96 to 27.28 MHz	32	1.0	1.0
40.66 to 40.70 MHz	50	1.5	1.5
Above 800 MHz	500	50.0	15.0

(d) The device shall be self-contained with no external or readily accessible controls which may be adjusted to permit operation in a manner inconsistent with the provisions of this section. Any antenna that may be used with the device shall be permanently attached thereto and shall not be readily modifiable by the user.

§ 15.193 Certification required.

(a) A device that uses RF energy to measure the characteristics of a material, that was manufactured prior to October 1, 1975, shall be certificated pursuant to §§ 15.135 and 15.136.

(b) A device that uses RF energy to measure the characteristics of a material, that was manufactured on and after October 1, 1975, shall be certificated pursuant to Subpart B of this part.

§ 15.194 Identification.

A device that uses RF energy to measure the characteristics of a material shall be identified pursuant to Subpart B of this part.

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE CHIEF ENGINEER
WASHINGTON, D. C. 20554

BULLETIN OCE 12
JULY 1977

Supersedes Issue of
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OPERATION IN THE BAND 535-1600 kHz WITHOUT AN INDIVIDUAL LICENSE

1.0 INTRODUCTION

1.1 General. The band 535-1600 kHz is allocated for broadcast stations. However, under the provisions of Part 15 of the Commission's Rules, a Low Power Communication Device or a Carrier Current System may be operated in this band without an individual license provided the operation meets all of the following conditions.

--No harmful interference is caused to any licensed operation.

--Any interference that is received must be accepted.

--The technical and other requirements of Part 15 are met.

1.2 Harmful Interference. Harmful interference is defined by the Commission as any emission, radiation, or induction which endangers a radionavigation or a safety service, or which seriously degrades, obstructs, or repeatedly interrupts other licensed radio services. Since this discussion deals with operation in the AM band (535-1600 kHz), the operator must take particular care to protect the broadcast service. See Information Bulletin No. 13 for a more detailed discussion of the interference problem.

The technical specifications imposed by Part 15 are purposely designed to limit the coverage that may be obtained in order to protect the broadcast service. Consequently, one should not expect to obtain radio coverage beyond about 100 meters (about 300 feet). In fact, coverage beyond 100 meters is usually an indication that the operation does not conform to these limits and violates the Part 15 Rules. Requests for permission to operate outside these limits will not be granted because relaxing these technical limits to permit extended coverage, greatly increases the interference potential to the broadcast service and cannot be permitted.

2.0 LOW POWER COMMUNICATIONS DEVICES

To emit radio waves, a miniature transmitter called a LOW POWER COMMUNICATION DEVICE is connected to a small antenna. This type of device may radiate RF energy to an AM receiver over a frequency range which includes the standard AM Broadcast Band (535-1600 kHz). Sections 15.111 and 15.113 of our Rules regulate such operations.

§15.111 Radiation limitation below 1600 kHz.

A low power communication device which operates on any frequency between 10 and 490 kHz or between 510 and 1600 kHz shall limit the radiation so that the field strength does not exceed the value specified in the following table:

Frequency (kHz)	Distance (meters)	Field strength (μV/m)
10 - 490	300	$\frac{2400}{F(kHz)}$
510 - 1600	30	$\frac{24000}{F(kHz)}$

Regulation 15.111 permits operation without regard to power or antenna length provided the output signal does not exceed the field strength determined by the formula given in the regulation. A person who does not have enough technical knowledge to understand this formula should operate under the alternative requirement given below.

§15.113 Alternative requirement for operation on frequencies between 510 and 1600 kHz.

In lieu of meeting the field strength limits of §15.111, a low power communication device may operate on any frequency in the band 510-1600 kHz provided it meets all the following conditions.

(a) The power input to the final radio stage (exclusive of filament or heater power) does not exceed 100 milliwatts.

(b) The emissions below 510 kHz or above 1600 kHz are suppressed 20dB or more below the unmodulated carrier.

(c) The total length of the transmission line plus the antenna, plus the ground lead (if used) does not exceed 3 meters.

(d) Low power communication devices obtaining their power from the lines of public utility systems shall limit the radiofrequency voltage appearing on each power line to 200 microvolts or less on any frequency from 510 kHz to 1600 kHz. Measurements shall be made from each power line to ground, both with the equipment grounded and with the equipment ungrounded.

Regulation 15.113 provides an alternative requirement for operation in the AM broadcast band based on power and antenna length. It imposes a limit of 100 milliwatts on the power input. The antenna must not be longer than 10 feet which includes the length of the antenna proper plus the length of the transmission line plus the length of the ground lead, if used. The rules also require that any RF energy emitted by the device on frequencies below 510 kHz or above 1600 kHz be suppressed at least 20dB below the unmodulated carrier. Finally, the rules impose a special requirement on transmitters that get their power from the regular AC power. This special requirement is that the RF energy fed back into the power lines must not be greater than 200 microvolts when measured from either side of the line to ground with the transmitter grounded and also when it is not grounded.

However whichever set of technical specifications is used, the operator may not cause harmful interference and must immediately stop operating when notified that he is causing harmful interference.

NOTE: The alternative provision in §15.113 will be restricted to hobbyists and home experimenters if the proposal in FCC Docket No. 20780 (41 FR 17938) is adopted. Low power transmitters manufactured for use in the standard AM Broadcast Band will then be required to comply with §15.111.

3.0 CARRIER CURRENT SYSTEMS

The second type of operation permitted by Part 15 is described as carrier current operation. In this form of operation (typically used for campus radio systems), the transmitter output is coupled into the AC power network in the building. The RF energy is carried along the wires to every AM receiver that is plugged into this network. Usually, the RF energy does not go beyond the power transformer. Because some of the RF energy leaks off the wires, receivers in the building that are near the wires will also pick up the signals. Section 15.7 of our rules provides for this type of operation.

§15.7 General requirement for restricted radiation devices.

Unless regulated under some other subpart of this part, any apparatus which generates a radiofrequency electromagnetic field functionally utilizing a small part of such field in the operation of associated apparatus not physically connected thereto and at a distance not greater than 157,000/F(kHz) feet (equivalent to $\lambda/2\pi$) need not be licensed provided:

(a) That such apparatus shall be operated with the minimum power possible to accomplish the desired purpose.

(b) That the best engineering principles shall be utilized in the generation of radiofrequency currents so as to guard against interference to established radio services, particularly on the fundamental and harmonic frequencies.

(c) That in any event the total electromagnetic field produced at any point a distance of 157,000/F(kHz) feet (equivalent to $\lambda/2\pi$) from the apparatus shall not exceed 15 microvolts per meter.

(d) That the apparatus shall conform to such engineering standards as may from time to time be promulgated by the Commission.

(e) That in the event harmful interference is caused, the operator of the apparatus shall promptly take steps to eliminate the harmful interference.

NOTE: Radio receivers, community antenna television systems, and low power communication devices are regulated elsewhere in Part 15 and are not regulated by this section.

The rules impose a limit on the amount of RF energy that the system is permitted to emit. This limit is 15 microvolts per meter ($\mu V/m$) at a distance of $\lambda/2\pi$, where λ is the wave length of the frequency that is used. This distance in feet is equal to 157,000 divided by the frequency in kHz. The 15 $\mu V/m$ limit must not be exceeded when measured at the specified distance from the transmitter or from any part of the wire network carrying the RF energy.

NOTE: Section 15.7 is currently under consideration for complete revision in FCC Docket No. 20780 (41 FR 17938).

4.0 CERTIFICATION

The FCC requires that a Low Power Communication Device be certificated to show that it has been tested and found to comply with the technical specifications in Part 15. The operator should make sure that his equipment carries the necessary certification label. In addition the operator should check his equipment from time to time to make sure that it continues to comply with these requirements.

Carrier Current Systems are not required to be certificated at present. However, in order to be sure that his operation continues to comply with the FCC requirements, the operator should make regular surveys--measurements of field strength around the installation--and keep the results of these surveys on file.

4.1 General Certification and Identification Requirement. Certification from the FCC is required for two categories of devices:
--A device manufactured after October 1, 1975 which is to be marketed.
--A device built in quantities of more than 5 which will not be marketed. For these devices the manufacturer files an application pursuant to Subpart B of Part 15 and Subpart J of Part 2. Commission grants certification after a review of data shows that the equipment can be expected to comply with technical specifications. The device must carry an identification label stating that the device complies with FCC Rules Part 15 and listing the trade name, model number and date of manufacture.

4.2 Certification and Identification for home built device. A person who constructs not more than five low power communication devices for his own use, and not for sale, is not required to submit the certification information to the Commission. Instead, he shall attach to each device a signed and

dated label that reads as follows:

I have constructed this device for my own use. I have tested it and certify that it complies with the applicable regulations of FCC Rules Part 15. A copy of my measurements is in my possession and is available for inspection.

(signature) (date)

5.0 MARKETING OF NON-CERTIFICATED DEVICES

The Commission's Marketing Rules, Sections 2.801-2.819, prohibit the import, sale, offer for sale or shipment of devices requiring certification, until such time as the Commission grants certification therefor.

6.0 CONDITIONS OF OPERATION

A LOW POWER COMMUNICATIONS DEVICE and CARRIER CURRENT SYSTEM are restricted radiation devices. These equipments must meet the applicable technical standards specified in Sections 15.7, 15.111 or 15.113. In addition, the following rules set out general conditions governing the operation of these equipments.

§15.3 General condition of operation.

Persons operating restricted or incidental radiation devices shall not be deemed to have any vested or recognizable right to the continued use of any given frequency, by virtue of prior registration or certification of equipment. Operation of these devices is subject to the conditions that no harmful interference is caused and that interference must be accepted that may be caused by other incidental or restricted radiation devices, industrial, scientific or medical equipment, or from any authorized radio service.

§15.5 Equipment available for inspection.

Any equipment or device subject to the provisions of this part [Part 15] together with any license, certificate, notice of registration or any technical data required to be kept on file by the operator of the device shall be made available for inspection by Commission representatives upon reasonable request.

§15.11 Prohibition against eavesdropping.

(a) No person shall use, either directly or indirectly, a device operated pursuant to the provisions of this part for the purpose of overhearing or recording the private conversations of others unless such use is authorized by all of the parties engaging in the conversation.

(b) Paragraph (a) of this section shall not apply to operations of any law enforcement officers conducted under lawful authority.

§15.103 Interference from low power communication devices.

Notwithstanding the other requirements of this part, the operator of a low power communication device, regardless of date of manufacture, which causes harmful interference to an authorized radio service, shall promptly stop operating the device until the harmful interference has been eliminated.

Interference from carrier current systems is governed by §15.7(e) which requires that the operator promptly take steps to eliminate such interference.

§15.105 Class B emission prohibited.

Operation of low power communication devices that produce Class B emissions (damped waves) is prohibited.

7.0 FREQUENCY SELECTION

The FCC does not designate the specific frequency to be used by a low power communication device. The operator of the device may select his own frequency in the band 535-1600 kHz. The operator must make sure however, that his selection of an operating frequency will not result in harmful interference to persons trying to receive broadcast signals.

8.0 OPERATOR REQUIREMENTS

There are no requirements as to age, sex, citizenship, etc. No operator license is required, but the operator is expected to be acquainted with the Part 15 rules applicable to his equipment.

9.0 PERMISSIBLE TRANSMISSIONS

As a general rule, the FCC does not concern itself with the type of material transmitted over a low power communication device or a carrier current system. However, the operator is cautioned that the transmission of obscene, indecent, or profane language is prohibited by Federal law and is punished by fine, or imprisonment, or both.

The operator of a low power communication device is also warned not to rebroadcast any program of a licensed broadcast station without the written permission of the originating station.

10.0 CALL SIGN

The FCC does not assign nor will it register call signs for the operator of a low power communication device. Any identification may be used provided it will not be confused with the call sign used by a licensed station.

11.0 HOURS OF OPERATION

The operator may select his own hours of operation.

12.0 SOURCES OF TECHNICAL INFORMATION

Information about the construction and operation of a low power communication device is published from time to time in the various popular technical journals. Files of these magazines are usually available in your local library. Information may also be found in the various technical hand books and guides found in most radio supply shops.

13.0 LICENSED OPERATION

The FCC will not issue a license for the operation of a low power station. Operation of a licensed broadcast station is a serious undertaking and a person applying for a license undertakes a commitment to provide a regular service meeting many requirements which are discussed in the bulletins listed below. Not only does the construction of a licensed station involve a substantial financial investment, but it also requires considerable legal and technical qualifications. Information on licensing will be found in: Information Bulletin 2 - How to Apply for a Broadcast Station. Information Bulletin 12 - Educational Radio.

14.0 OPERATION PROHIBITED IN FM BAND

Due to the physical laws of radio propagation on frequencies in the AM band, operation with low power and a small antenna is inherently short range. Thus, it is possible to set up operating conditions in the AM band that will protect the broadcast service and still provide a reasonable operating range for the owner of a low power communication device.

This cannot be done in the FM band (88-108 MHz). Conditions in this band are completely different and long range transmission is possible even with extremely low power--a fact that is well known and well documented. In the fact of this physical phenomenon, the Commission has not found it possible to set up operating conditions on the FM band that would provide a reasonable operating range. Accordingly, operation without an individual license for low power broadcasting in the FM band is strictly prohibited.

For a discussion of radio wave propagation and transmission range of radio signals, the reader should refer to text books on the subject of radio available in libraries. Index search under the term radio wave propagation should lead to the desired information.

15.0 DEFINITIONS

The following terms used in this Bulletin have been defined by the Commission and their definitions are listed below.

§15.4 General definitions.

* * * * *

(b) Harmful interference. Any emission, radiation or induction which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radiocommunication service operating in accordance with this chapter.

* * * * *

(d) Restricted radiation device. A device in which the generation of radiofrequency energy is intentionally incorporated into the design and in which the radiofrequency energy is conducted along wires or is radiated, exclusive of transmitters which require licensing under other parts of this chapter and exclusive of devices in which the radiofrequency energy is used to produce physical chemical or biological effects in materials and which are regulated under the provisions of Part 18 of this chapter.

(e) Marketing. Marketing shall include sale or lease, offer for sale or lease, advertising for sale or lease, the import or shipment or other distribution for the purpose of sale or lease or offer for sale or lease.

NOTE: In the foregoing sale (or lease) shall mean sale (or lease) to the user or vendor who in turn sells (or leases) to the user. Sale shall not be construed to apply to devices sold to a second party for manufacture or fabrication into a device which is subsequently sold (or leased) to the user.

(f) Low power communication device. A low power communication device is a restricted radiation device, exclusive of those employing conducted or guided radiofrequency techniques, used for the transmission of signs, signals (including control signals), writing, images and sounds or intelligence of any nature by radiation of electromagnetic energy.

EXAMPLES: Wireless microphone, phonograph oscillator, radio controlled garage door opener and radio controlled models.

CAUTION

REMEMBER -- YOU MAY NOT CAUSE HARMFUL INTERFERENCE.

REMEMBER TOO -- WHEN YOU ARE NOTIFIED THAT YOUR OPERATION IS CAUSING HARMFUL INTERFERENCE, YOU MUST STOP OPERATING IMMEDIATELY.

POSTSCRIPT

To conclude, I would like to mention that this 4th edition of my scrapbook series has been in preparation for over 3 years....Every time I thought I had the text finished, something new circuit-wise would come up and back to the soldering iron and perf-board....By the time you read this, there will probably be new solid-state gimmicks available that will out-date my circuits, but golly darn, you have to start someplace !

No matter how you look at it, electromagnetic radiation (commonly called RADIO) is a very important means for dissemination of any type of intelligence.

Regardless of the frequency, power and antenna restrictions, the use of same should be considered for personal and scientific gains that are only limited by your imagination.

I might mention that there is a group of radio buffs scattered about the World that monitor the field strength of known VLF stations in relation to Solar Flares....They are really "gung-ho" and use very sophisticated recording devices tied in with dates and time....A SASE to Casper (Cap) Hossfield, 119-B 2nd Street, Mahwah, NJ 07430 should get some info....Cap publishes a very interesting VLF Experimenters News Letter....Some of these experimenters even use magnemometers (sp ?) to record changes in the Earth's magnetic lines of force during Solar Flare Activity.

Most Radio Hams are familiar with the skip and fade conditions that are encountered on the higher frequencies and these are accepted and can be fairly accurately predicted during the Sun Spot Cycles over the years.

In the LF to VLF range, we should not expect to experience these skip conditions, yet on many occasions I have monitored LOWFERS Beacons at +/- 100 miles and have observed a very slow noticeable fade that can run some 1 to 3 minutes between peaks....My thinking is that our mini power is radiated along the ground and between some layer in the upper atmosphere acting like a wave guide....If this space contracts it will act as an aperture and reduce the signal strength and if it increases, it will strengthen the received signal ?

I am convinced however, that the magnetic lines of force assist our radiated power....All reports I have received on DX contacts or the reception of LOWFERS Beacons in the 200 + mile range is always in the North/South path....Not East/West....Something to think about ?

The above thoughts is only my personal thinking after fooling with the low frequency range for over 10 years and if anyone can prove otherwise, I would be pleased to hear their comments....Please understand that I am talking about a one watt transmitter working into a 15 meter long antenna and NOT megawatts working into acres of antennas !

POSTSCRIPT, cont'd.

With the exception of "E" Cores and Bobbins, all parts and devices I call for in the circuit diagrams should be available at most any well stocked radio part supply store....Due to their many locations, I also list the part numbers for Radio Shack catalog items....A SASE to yours truly, will get you the info on "E" Cores and Bobbins.

For readers that have to resort to "mail order houses", if you do not have your favorite, a review of the adds in any radio hobby magazine should take care of your needs.

An example....I recently received a catalog (#824, July-Aug. '82) from DIGI-KEY Corp., P.O. Box 877, Thief River Falls, MN 56701 and for the "heck-of-it", I reviewed their prices for some of the solid-state devices shown in my circuits as follows:-

MPF-102.....54¢
4007.....36¢
4011.....37¢
4013.....60¢
4016.....45¢
4024.....76¢
4027.....56¢
4047.....97¢
4049.....47¢
LM78L15.....41¢
LM317.....$1.59

They also list color coded flat ribbon cable #28 AWG (7/38) tinned copper wire that is ideal for a box-loop antenna in 10 ft. lengths. This would make a square loop 2-1/2 ft. on a side and offer 14, 16, 20, 24, 26, 34, 40 and 50 wires....For the 10 ft. lengths, prices run from $3.75 for the 14 conductor up to $13.50 for the 50 conductor.

They have a service charge of $2 for orders under $10 and diminishing amounts up to $100....This is typical for most mail-order houses and I suggest that if dealing with them thru an add, read the fine print as to terms.

I am not promoting the purchase of parts from any source that I mention in this text as it is only included for the convenience of the reader for reference purposes, and as the old saying goes "let the buyer beware".

73
/
Ken, W2IMB